GROLIER

ENCYCLOPEDIA OF KNOWLEDGE

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Grolier Incorporated
Danbury, Connecticut

1993 Printing

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ISBN 0-7172-5300-7 (complete set)
ISBN 0-7172-5318-X (volume 18)

Printed and manufactured in the United States of America.

This publication is an abridged version of the *Academic American Encyclopedia.*

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suede Suede is the finish given to lambskin or kidskin leather by running the flesh side of the skin over a carborundum or emery buffing wheel to separate the fibers. The surface becomes silken and napped. Leather or cowhide with the top grain "split" off may also be buffed, producing a nappy surface somewhat rougher in texture and called brushed leather or sueded cowhide. Suede is used for footwear, apparel, handbags, belts, and gloves. The word *suede*, French for "Sweden," refers to *gants de Suede*, elegant sueded kidskin gloves originally made in Sweden.

Suess, Eduard [zoos] Eduard Suess, b. Aug. 20, 1831, d. Apr. 26, 1914, was an Austrian geologist and professor at the University of Vienna whose work formed the basis for the whole field of structural geology. From his early work on fossils, Suess was led to investigate how mountains were formed. His greatest work, *Das Antlitz der Erde* (The Face of the Earth, 1883–1909), presented a comprehensive view of global geological formations and their evolution. It includes his recognition that earthquakes are caused by moving landmasses and that changes in ancient shorelines occurred because of variations in sea level.

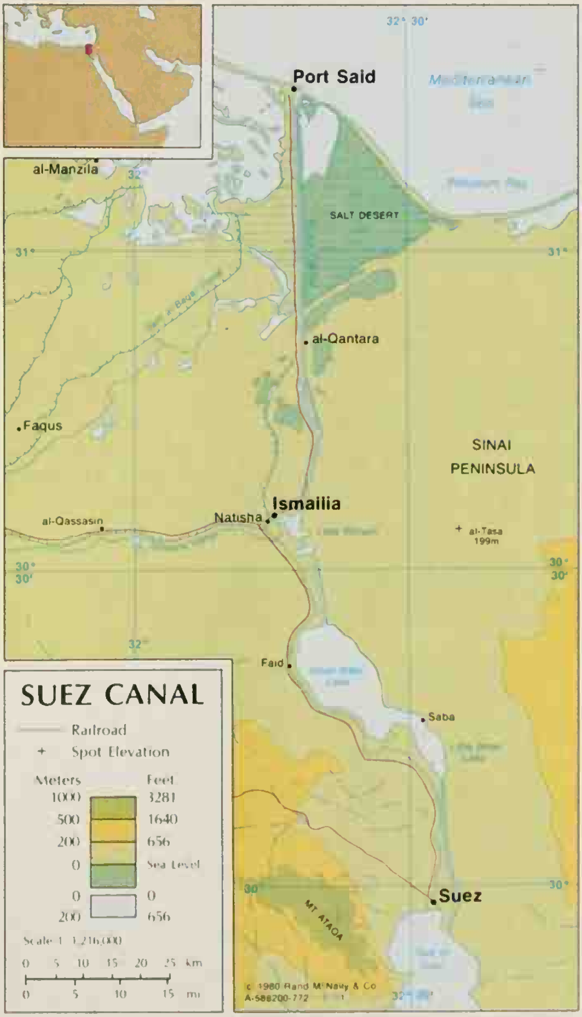
Suetonius [swee-toh'-nee-uhs] Gaius Suetonius Tranquillus, known as Suetonius, AD *c.*69–*c.*140, was a Roman biographer best known for his often scandalous *Lives of the Caesars* (AD *c.*121), which recounts the histories of Julius Caesar and of Rome's first 11 emperors, from Augustus to Domitian. Translated by Robert Graves as *The Twelve Caesars* (1957), it had earlier inspired Graves's novels *I, Claudius* and *Claudius the God* (both 1934). Suetonius also wrote *De viris illustribus* (On Illustrious Men, *c.*113), 34 biographies of Roman writers, most of which has been lost.

Suez [soo-ez'] Suez is a port city and the capital of Suez governorate, Egypt, located about 130 km (80 mi) east of Cairo. The population is 326,820 (1986). The city lies on a sandy plain at the head of the Gulf of Suez and at the southern end of the Suez Canal. Suez is especially noted for its petroleum facilities—storage, refining, and manufacturing of by-products—and much of its petroleum flows to Cairo by pipeline. Chemical fertilizer and paper products are also manufactured, and the city has important rail connections with Cairo and Ismailia. Suez is a starting point for Muslim pilgrimages to Mecca in Saudi Arabia.

Remains of earlier settlements on the site (Clysma and Arsinoë) date from ancient Egyptian times, and the city has grown and declined through the centuries with the opening and closing of trade routes. Its modern importance dates to the opening of the Suez Canal in 1869.

Suez Canal The Suez Canal, located at the crossroads of Asia, Europe, and Africa, is one of the world's most important waterways. Opened in 1869, the sea-level artificial waterway crosses the narrow Isthmus of Suez joining Africa and Asia and permits oceangoing vessels to travel between the eastern end of the Mediterranean Sea and the Indian Ocean via the Gulf of Suez and Red Sea. The canal is owned and operated by Egypt and separates the main part of that country on the west bank from the SINAI Peninsula on the east bank.

The northern terminus is PORT SAID on the Mediterranean Sea. The canal extends southward in a nearly straight line across the eastern edge of the salt-marsh area of Lake Manzala and over the red desert soils of the isthmus to reach its midpoint at the northern end of Lake Timsah. It continues southward through Lake Timsah, where Ismailia and the administrative headquarters of the canal are located, then southward and southeastward through the Great and Little Bitter lakes (now a single lake) and southward again past the city of Suez to reach the Gulf of Suez at Port



Taufiq. The canal has a total length—including channel approaches at each end—of 169 km (105 mi) and handles about 60 vessels a day. Widened and deepened over the years, it now accommodates ships with a maximum draft of 16.2 m (53 ft). No locks interrupt traffic, and transit time averages about 15 hours.

The canal is strategically and economically important because it shortens the distance between Europe and the Far East. The USSR uses the canal to move its navy from the Mediterranean to the Indian Ocean. Between 1975 and 1980, in a major expansion project, the canal was widened and deepened to enable it to accommodate larger vessels. Of the 200–300 million tons of annual freight, about 30–40% is petroleum.

The present water route between the two oceans was preceded as early as the 19th century BC by an east-west canal from the Nile River to the Red Sea. In 1854 and 1856, Ferdinand de LESSEPS obtained rights from Said Pasha, khedive of Egypt, to establish a company to build and operate for 99 years a canal open to the ships of all nations. Construction was completed in 1869 at more than double the originally estimated cost of $41,860,000. The United Kingdom acquired a controlling interest in the company when the debt-ridden khedive, ISMAIL PASHA, was forced to sell his holdings in 1875.

In 1888 freedom of passage for all ships of all nations in peace and in war was guaranteed by the Convention of Constantinople. Israel was, however, denied passage after the first of the ARAB-ISRAELI WARS, although cargoes destined for Israel on non-Israeli ships were permitted in 1952–53, 1957–59, and after 1975. Egypt's President Gamal Abdel NASSER precipitated the Suez Crisis on July 26, 1956, by nationalizing the canal company 12 years before the 99-year lease was to end and by blocking Israel's access to the Strait of Tiran and the Gulf of Aqaba. In October 1956, Israel occupied the Sinai Peninsula, and the United Kingdom and France occupied positions along the canal. The canal was reopened to non-Israeli traffic in April 1957 and turned over to Egypt, which eventually compensated the former shareholders in 1958.

A ship cruises along the Suez Canal between Ismailia and the Great Bitter Lake. The Suez Canal remains an important avenue for commercial traffic between Europe and Asia.

During the Six-Day War (1967) between Egypt and Israel, ships were sunk by Egypt to block the waterway, and it remained closed for 8 years. Israeli shipping rights were restored by the 1979 Egyptian-Israeli peace treaty. In 1980, 21,603 vessels passed through the canal. That same year, the first of several tunnels under the canal opened.

Suez Crisis The Suez Crisis (1956) developed when Great Britain, France, and Israel retaliated against Egypt for nationalizing the Suez Canal. Egyptian president Gamal Abdel NASSER, angered by the withdrawal by the United States and Great Britain of an offer to finance the Aswan High Dam project, nationalized the canal on July 26. The British government, which held nearly half the shares in the Suez Canal Company, tried to block that move. Together with France, which resented Egyptian aid to Algerian rebels, and Israel, Britain planned to take over the canal. Israel launched a strike against the Sinai Peninsula on October 29. The next day Britain and France demanded that the combatants withdraw 16 km (10 mi) from the canal and then attacked Egypt from the air when it refused the demand. On November 5, Anglo-French troops landed near Port Said. Egypt's Arab neighbors did not come to its aid, but the USSR threatened to retaliate with nuclear weapons. The United States, working through the United Nations, demanded a cease-fire. One was put into effect on November 6, and a supervisory police force established by the United Nations took over on Mar. 7, 1957.

See also: ARAB-ISRAELI WARS.

Suffolk (county) [suhf'-uhk] Suffolk is a county in eastern England with an area of 3,797 km^2 (1,466 mi^2) and a population of 638,500 (1988 est.). The terrain is mainly low-lying, and the county is bordered on the east by the North Sea. The county seat is Ipswich. Other major towns are BURY ST. EDMUNDS and Lowestoft. Suffolk is drained by the Waveney, Stour, Deben, Orwell, and Alde rivers. The economy is based on the cultivation of grains and vegetables, but fishing, brewing, food processing, horse breeding, and tourism are also important.

Stone, Bronze, and Iron Age remains have been found. Burgh Castle, a popular tourist attraction, dates from the Roman period. Suffolk was part of the Anglo-Saxon kingdom of East Anglia. From the High Middle Ages until the beginnings of the Industrial Revolution, Suffolk's prosperity was based on the manufacture of woolen fabric and garments.

Suffolk (horse) see HORSE

Suffolk, William de La Pole, 4th Earl and 1st Duke of The English statesman William de La Pole, 4th earl and 1st duke of Suffolk, b. Oct. 16, 1396, d. May 2, 1450, played significant political and military roles in the later stages of the HUNDRED YEARS' WAR. In 1444 he brought about a truce with France by ceding the provinces of Anjou and Maine to France and arranging the marriage of King Henry VI of England to Margaret of Anjou, niece of the French king. This action brought Suffolk to the peak of his influence, and in 1448 he was made a duke. A year later, however, the English violated the peace agreement—probably with Suffolk's approval—thus enabling French armies to seize all English holdings in France except for Calais. Impeached by the House of Commons, Suffolk was banished from England, but he was intercepted as he left the country and murdered.

suffrage Suffrage is the right or exercise of the right to vote in public affairs. Suffrage, also called franchise, has been viewed as a right, as a privilege, or as a duty. As a right, it is conceived of as an inalienable attribute inherent in the individual. This view has led to the extension of the franchise to include more and more people. As a privilege, suffrage is considered as being conferred on the individual by law and is subject to limitations imposed by governing authorities. It therefore can be restricted to some special parts of the population. Some theories rely on the classical Greek concept of the exercise of the suffrage as the citizen's duty to participate actively in the welfare of the community.

Today universal or near-universal suffrage prevails in most of the world, although the extent to which true choice may be exerted varies widely. The requirements of voting show great uniformity in different regions and under different systems of government. The franchise is almost invariably limited to citizens of a minimum age between 18 and 25, depending on the country, and to residents of the locality. Excluded are the mentally ill and convicted felons. In some nations women's suffrage is still subject to qualifications. In other parts of the world property ownership and racial requirements for voting may be enforced. These qualifications for suffrage, and others based on religion, education, and taxpaying, were universal until the 19th century.

In the United States at the time the Constitution was written, it is estimated that only 6 percent of the adult male population was entitled to vote. Under the influence of Jeffersonian and Jacksonian democracy, religious and property qualifications were eliminated. Racial barriers to voting existed legally until the 15th Amendment was ratified after the Civil War. Thereafter, blacks were excluded from the franchise in some states through such devices as the white primary, the poll tax, literacy tests, and grandfather clauses. These were gradually interpreted to be unconstitutional under the 15th Amendment or under the equal-protection-of-the-laws clause of the 14th Amendment. Women were given the franchise in 1920 under the 19th Amendment, and the right to vote was extended to 18-year-olds in 1971 under the 26th Amendment.

suffrage, women's The struggle to achieve equal rights for women is often thought to have begun, in the English-speaking world, with the publication of Mary Wollstonecraft's Vindication of the Rights of Women (1792). During the 19th century, as male suffrage was gradually extended in many countries, women became increasingly active in the quest for their own suffrage. Not until 1893, however, in New Zealand, did women achieve suffrage on the national level. Australia followed in 1902, but American, British, and Canadian women did not win the same rights until the end of World War I.

(Left) *Susan B. Anthony led the early movement to achieve women's suffrage in the United States.*

WE WERE VOTERS OUT WEST!
WHY DENY OUR RIGHTS IN THE EAST?

(Below) *American suffragists struggled for women's rights throughout the 19th and into the 20th century. Nine western states had enfranchised women by 1912. The 19th Amendment (1920) finally ensured voting equality.*

The United States. The demand for the enfranchisement of American women was first seriously formulated at the Seneca Falls Convention (1848). After the Civil War, agitation by women for the ballot became increasingly vociferous. In 1869, however, a rift developed among feminists over the proposed 15th Amendment, which gave the vote to black men. Susan B. Anthony, Elizabeth Cady Stanton, and others refused to endorse the amendment because it did not give women the ballot. Other suffragists, however, including Lucy Stone and Julia Ward Howe, argued that once the black man was enfranchised, women would achieve their goal. As a result of the conflict two organizations emerged. Stanton and Anthony formed the National Woman Suffrage Association to work for suffrage on the federal level and to press for other rights for women. Stone created the American Woman Suffrage Association, which aimed to secure the ballot through state legislation. In 1890 the two groups united under the name National American Woman Suffrage Association (NAWSA). In the same year Wyoming entered the Union, becoming the first state with general women's suffrage (which it had adopted as a territory in 1869).

One of the most politically astute suffragists of the early 20th century was Carrie Chapman CATT, who was named president of NAWSA in 1915. Alice PAUL, another prominent suffragist, organized the National Woman's party, which used such strategies as mass marches and hunger strikes. Perseverance on the part of both organizations eventually led to victory. On Aug. 26, 1920, the 19th Amendment granted the ballot to American women.

Great Britain. In Great Britain the cause began to attract attention when the philosopher John Stuart Mill presented a petition in Parliament calling for inclusion of women's suffrage in the Reform Bill of 1867. In the same year Lydia Becker (1827–90) founded the first women's suffrage committee, in Manchester. Other committees were quickly formed, and in 1897 they united as the National Union of Women's Suffrage Societies, with Millicent Garret Fawcett (1847–1929) as president. Frustrated by the prevailing social and political stalemate, some British suffragists became more militant. Emmeline Pankhurst, assisted by her daughters Christabel and Sylvia (see PANKHURST family), founded (1903) the Women's Social and Political Union. Her followers, called "suffragettes," heckled politicians, practiced civil disobedience, and were frequently arrested for inciting riots, When World War I started, suffragists ceased their activities and supported the war effort. In February 1918 women over the age of 30 received the right to vote. Suffrage rights for men and women were equalized in 1928.

Other Countries. Such European countries as Finland (1906), Norway (1913), and Denmark and Iceland (1915) granted women the vote early in the 20th century. The USSR and the Netherlands granted suffrage in 1917; Austria, Czechoslovakia, Poland, and Sweden in 1918; and Germany and Luxembourg in 1919. Spain extended the ballot to women in 1931, but France waited until 1944 and Belgium, Italy, Romania, and Yugoslavia until 1946. Switzerland finally gave women the vote in 1971, and women remained disenfranchised in Liechtenstein until 1984.

In Canada women won the vote in Alberta, Manitoba, and Saskatchewan in 1916; after federal suffrage was achieved in 1918, the other provinces followed suit, the last being Quebec in 1940. Among the Latin American countries national women's suffrage was granted in 1929 in Ecuador, 1932 in Brazil, 1939 in El Salvador, 1942 in the Dominican Republic, 1945 in Guatemala, and 1946 in Argentina. In India women were enfranchised on the same terms as men in 1935; in the Philippines they received the vote in 1937, in Japan in 1945, in China in 1947, and in Indonesia in 1955. In African countries men and women have generally received the vote at the same time, as in Liberia (1947), Uganda (1958), and Nigeria (1960). In many of the Middle Eastern countries universal suffrage was acquired after World War II, although women remain totally disenfranchised in some countries, for example, Kuwait.

Sufism [soo'-fizm] The word *Sufism*, which is probably derived from the Arabic *suf* ("wool"; hence *sufi*, "a person wearing an ascetic's woolen garment"), denotes Islamic mysticism. Although outside movements have had some influence on Sufi terminology, Sufism is definitely rooted in ISLAM itself. Its development began in the late 7th and early 8th centuries when worldliness and loose morals in ruling UMAYYAD circles evoked a strong reaction among certain pious persons. Such individuals as Hasan of Basra (d. 728) urged the Muslim community to heed the Koranic call to fear God, its warnings for Judgment Day, and its reminders of the transitoriness of life in this world. A new emphasis on the love of God brought the transition to mysticism. The woman saint Rabia of Basra (d. 801) called for love of God "for his own sake," not out of fear of hell or hope for heaven.

Sufism was early criticized by those who feared that the Sufis' concern for personal experiential knowledge of God could lead to neglect of established religious observances and that the Sufis' ideal of unity with God was a denial of the Islamic principle of the "otherness" of God. The execution (922) of al-Hallaj, who claimed mystical communion with God, is related to this second issue, and in later centuries some Sufis did indeed move to a theosophical monism (for example, Ibn Arabi, d. 1240; and Jili, d. *c.*1428). By combining a traditional theological position with a moderate form of Sufism, al-GHAZALI made mysticism widely acceptable in the Muslim world.

Sufism exercised a tremendous influence, partly through mystical poetry, for example, that of Jalal al-Din al-RUMI, and partly through the formation of religious brotherhoods.

See also: DERVISH.

sugar Sugars, a diverse and important subdivision of naturally occurring organic compounds called CARBOHYDRATES, are generally sweet tasting, dissolve easily in water, and form white or clear crystals when purified. Common table sugar, or sucrose, is but one of many kinds of sugars. PHOTOSYNTHESIS serves to manufacture sugars as a food source for plants.

Types. Simple sugars, or MONOSACCHARIDES, have three to seven carbon atoms, in either a chain or a ring structure. Glucose (also called grape sugar or dextrose) and fructose (fruit sugar) are representative monosaccharides. Glucose is the sugar into which all digested carbohydrates are metabolized in the body; the term *blood sugar* refers to glucose levels in the blood. Malfunction of glucose METABOLISM can result in low blood sugar (HYPOGLYCEMIA) or high blood sugar (DIABETES). Glucose is used commercially as a sweetener, especially in wines and drugs. Fructose is used both as a sweetener and as a food preservative. A genetic defect resulting in a failure to convert galactose—a monosaccharide sugar naturally found in the brain—to glucose is known as GALACTOSEMIA and can cause mental retardation. The simple sugars ribose and deoxyribose are major constituents of the nucleic acids RNA and DNA, respectively.

Disaccharides consist of two simple sugars linked together. Maltose (malt sugar), for instance, is composed of two glucose molecules, and lactose (milk sugar) consists of a glucose and a galactose molecule. Sucrose can be broken down into the simple sugars glucose and fructose. Large chains of simple sugars form such POLYSACCHARIDES as cellulose, glycogen, and starch.

Sucrose. Sugarcane and sugar beets are the principal commercial sources of sucrose (see SUGAR PRODUCTION). Raw sugarcane contains from 7% to 20% sucrose, 8% to 16% fiber (mostly cellulose), and 70% to 75% water. Maple sap, sorghum, and some palm or date trees also yield limited quantities of sucrose. The sugar-refining industry, which has grown rapidly since the mid-19th century, is based on the extraction and purification of sucrose. In addition to its use as a food, sucrose is used to manufacture certain detergents, plastics, and related compounds. Efforts are also being made to synthesize other organic chemicals from sucrose to conserve dwindling supplies of petroleum.

Nutrition. Sugars are rapidly digested (see DIGESTION, HUMAN) and provide a quick source of energy. They play an important but often controversial role in the DIET (see NUTRITION, HUMAN). Artificial sweeteners, such as saccharin and cyclamates, were developed to replace naturally occurring sugars in food products. The Food and Drug Administration, which has banned cyclamates and enforces controls on the use of saccharin, approved in 1981 the sale of aspartame, a naturally occurring amino sugar that is 200 times sweeter than sucrose. The sugar fructose is also being tested as a substitute for sucrose.

sugar beet The sugar beet is one of the cultivated forms of the plant *Beta vulgaris.* A biennial, it is harvested annually for its roots, which are the source of one-third of the world's sugar. Sugar beets are one of the newest commercial crops and are unique in that their development has been well documented. Starting in the late 18th century, German scientists began to selectively breed beets to raise the sugar content of their roots from 1–4 percent to 15–20 percent. The resulting beet root has white flesh and skin and a sharply tapered shape. Sugar beets are cultivated commercially throughout the world but are concentrated in cooler areas where cane sugar plants cannot grow. The principal national producers are the USSR, the United States, Italy, France, Poland, and Germany. In the United States, sugar beets are grown in the western states, chiefly in California, Colorado, Idaho, Montana, and Nebraska. Sugar beets are harvested 20 to 30 weeks after the seeds are planted.

The root of sugar beets yields a substantial amount of the world's total sugar. Beet tops and by-products of the sugar-extraction process are used as animal feed.

sugar production Sugar production is the cultivation and harvesting of sucrose-rich plants and the conversion of the sucrose into crystallized sugar. The major plant sources of sucrose are sugarcane and the SUGAR BEET. Less important sources include maple-tree sap, sorghum cane, wild date palms, watermelons, and grapes.

History. It is believed that sugarcane culture began in New Guinea and gradually spread throughout the South Pacific, Asia, and the ancient Arab world. Sugar remained a scarce luxury in Europe. In the 15th and 16th centuries, however, European explorers and colonizers of South America and the Caribbean brought sugarcane cuttings with them. The cuttings thrived in the warm, moist climate and productive soil. By the year 1600, sugar production in the subtropical and tropical Americas was the world's largest and most lucrative industry.

Sugarcane culture and sugar production began in the United States with the planting of cuttings in New Orleans during the 1600s, and by 1689 the first sugar refinery was in operation in New York City.

Sugarcane remained the major source of sugar until the 18th century, when a German chemist, Andreas Marggraf, discovered that the sucrose in beets had the same chemical composition as that in sugarcane. When one of his students, Franz Karl Archard, developed a practical method for extracting sugar from beets in 1787, sugar-beet culture spread rapidly to France, Austria-Hungary, and Russia. This expansion led to the construction of the world's first beet-sugar factory in Germany in 1803 and to the further spread of sugar-beet cultivation throughout Europe and North America.

Cultivation and Refining. Glucose is manufactured in the leaves of all green plants and is converted there to sugar (sucrose) for transportation to stems and roots. In most plants, the sucrose is further converted to starch. Sugarcane and sugar beets are unusual in that not only do they make sucrose in great quantities but they also store it unchanged.

Sugarcane requires a warm, moist climate for cultivation. It is grown from sections of cane stalk, each containing a bud. After 9 to 36 months of growth the cane attains heights of 3–4.5 m (10–15 ft). At harvest, the cane is cut off close to the ground by machinery or manually with a heavy knife.

The cut stalks are stripped of leaves and sent to a sugar mill. There the cane juice is extracted, clarified, and concentrated by boiling. The remaining solid material, called bagasse, may be used as a fuel or processed into paper or wallboard. The thick cane syrup is fed into a centrifuge. When the centrifuge is spun, some of the syrup is crystallized and retained in a central basket, while the remaining syrup is thrown to the periphery. This process is repeated once or twice to extract additional sugar crystals. The residue is a dark, odorous syrup called blackstrap MOLASSES.

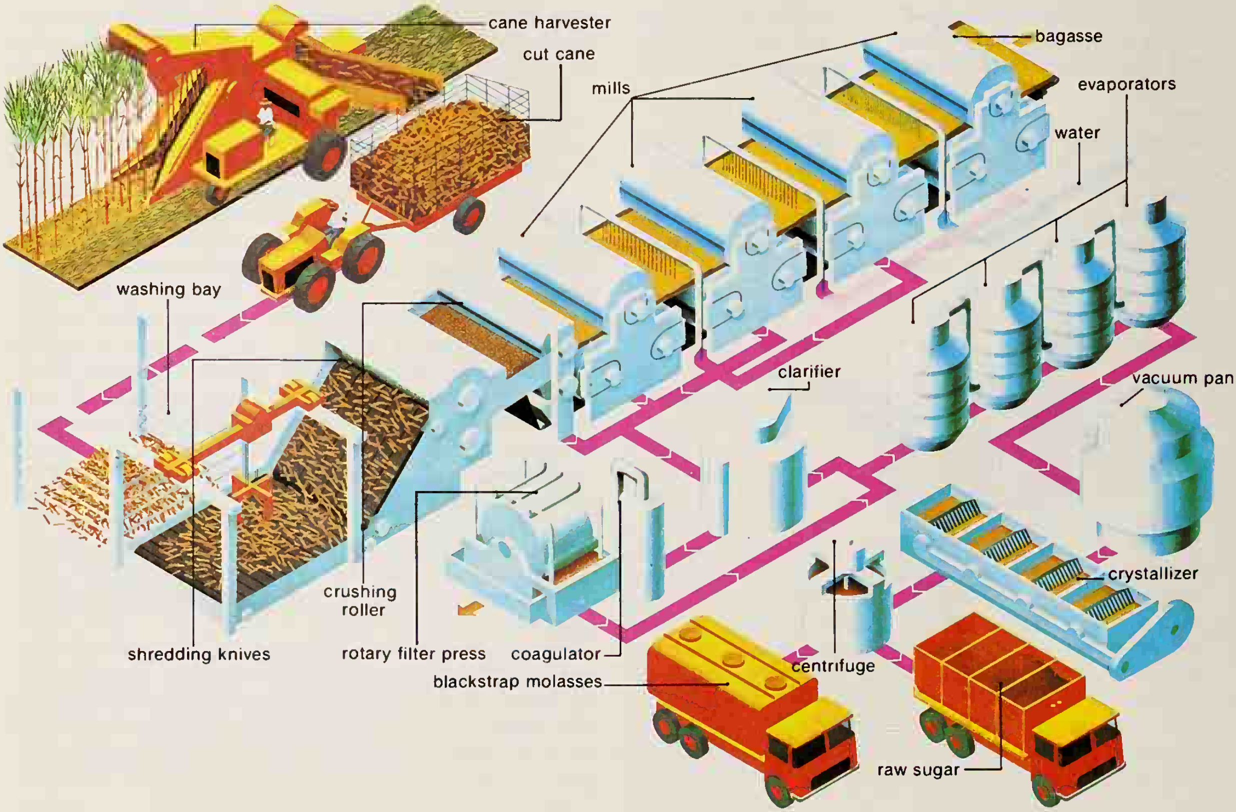
At this stage the sugar crystals are known as raw cane sugar and are light brown because they are coated with a thin film of molasses. The raw sugar is shipped to a refinery, where it is washed to remove the molasses and is dissolved into a water syrup. After the syrup is filtered to remove impurities and discolorants, the sugar is crystallized by boiling, washing, and centrifuging. The crystallization process is repeated as long as extractable sugar remains in the syrup. The end product is the familiar granulated white sugar.

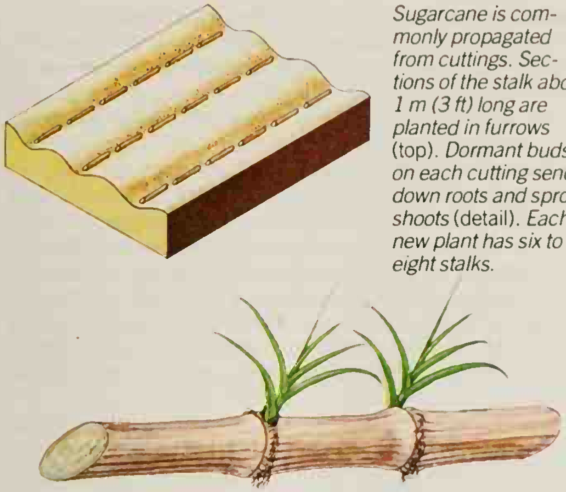
Brown sugar, technically known as soft sugar, is extracted from the syrup remaining after the granulated white sugar has been removed. The resultant product is a mass of fine crystals covered with a film of colored, molasses-flavored syrup.

Sugar beets are put through a single, continuous process. When mature, the beets are unearthed, their leafy tops removed for cattle feed, and the roots taken to the factory. There they are washed, machine-sliced into thin strips, and placed in large tanks, where they are treated with hot water to dissolve the sugar. The beet-pulp residue is used as cattle feed. The beet-sugar juice is purified, filtered, concentrated, and crystallized in a series of operations similar to those used in refining raw cane sugar.

Because of the strong flavor of sugar-beet molasses, brown sugar is not ordinarily made from sugar beets. White granulated beet sugar, however, is indistinguishable from granulated cane sugar, and the two products

Sugarcane is cut by hand or by a mechanical harvester, then sent to a nearby mill where the sugar is extracted. The stalks are first washed, shredded, and crushed between two rollers. The cane chips then pass through a series of mills where heavy rollers under tremendous pressure extract the juice. The solid residue, called bagasse is sprayed with water to dissolve more sugar before it passes to the last mill. The juice is heated in a clarifier, and milk of lime is added to precipitate impurities. Water is removed in a series of evaporators, and the resulting syrup is heated in vacuum pans, where it is reduced to massecuite—a mixture of sugar crystals and molasses. The thick syrup passes to a crystallizer and finally to a centrifuge, where the sugar crystals are separated, producing blackstrap molasses and raw sugar.





Sugarcane is commonly propagated from cuttings. Sections of the stalk about 1 m (3 ft) long are planted in furrows (top). *Dormant buds on each cutting send down roots and sprout shoots* (detail). *Each new plant has six to eight stalks.*

are chemically identical.

Sugar Grades. Granulated sugar is classified on the basis of crystal size. "Extra fine" and "fine" are the grades usually packaged as granulated sugar. "Super fine" is a quick-dissolving sugar used in baked goods and drink mixes. Coarser grades of granulated sugar are used by the baking and confectionery industries for special purposes.

Brown sugars are classified by color, and their flavor increases with darkness. For household use, two grades, light and dark, are generally available.

Confectioner's, or powdered, sugar is classified as 10X, 6X, or 4X, the higher numbers indicating the most finely powdered grades. Confectioner's sugar is used for icings, frostings, and the dusting on cakes and confections.

Turbinado sugar is partially refined sugar made by processing raw sugar crystals in a centrifuge and then washing them with steam. The final product, a light tan due to a thin molasses coating, is more than 99% pure sugar.

Invert sugar is a product used by the food industry for its distinctive flavor and because it confers moisture-retaining properties to baked goods, icings, and preserves. It is made by splitting the sucrose molecule into its two constituent sugars: dextrose (glucose) and levulose (fructose).

Liquid sugars, or sugar syrups, are solutions of highly purified sugar used by the food industry.

Sugar Production. The world's largest producers of cane sugar are Brazil, India, Cuba, China, Mexico, the United States, and Pakistan. Major producers of beet sugar include the USSR, France, the United States, Germany, and Turkey.

Cane-sugar production in the United States is concentrated in Hawaii, Florida, Louisiana, Texas, and Puerto Rico. The U.S. beet-sugar crop is grown mainly in the western states.

Suger, Abbot of Saint-Denis [sue-zhay'] Suger of Saint-Denis, b. *c.*1081, d. Jan. 13, 1151, was a leading French cleric and royal counselor. Becoming abbot of the monastery of Saint-Denis near Paris in 1122, he worked to enhance the abbey's strong ties to French royalty. His reconstruction of the church of SAINT-DENIS produced an early example of the Gothic architectural style. From about 1127 until his death, Suger was a close advisor to two French kings. He wrote a biography of the first of them, LOUIS VI, with whom he had been educated at Saint-Denis, and he headed the council of regency while the second, LOUIS VII, was on crusade (1147–49). Influenced by his contemporary, Bernard of Clairvaux, Suger helped shape royal perceptions of French feudalism as an ordered hierarchical system.

Suharto [soo-hahr'-toh] The Indonesian army officer Suharto, b. June 8, 1921, became president of Indonesia in 1968. He joined the Indonesian army in 1943 and fought for independence from the Dutch. In 1965, Suharto, by then a major general, led the army in a bloody defeat of an attempted Communist coup. He ousted President Sukarno and became acting president in 1967. Reelected in 1973, 1978, 1983, and 1988, Suharto ensured the military's preeminence and focused on economic development.

Sui (dynasty) [sway] The brevity of China's Sui dynasty (581–618) gives little indication of its significance as precursor of the second great imperial age, which began with the Tang dynasty. The first Sui emperor, **Yang Jian (Sui Wen Di)** (541–604; r. 581–604), conquered the Northern Zhou and Zhen dynasties, uniting China for the first time in almost four centuries.

From his capital at Daxian (later Chang'an), Wen Di directed such projects as repair of the Great Wall and a canal system linking the fertile central region with the northern plain. He sent expeditions to check the Turks on the Central Asian steppe and exact tribute from states as far east as Korea and as far south as Annam. His son and successor, the lustful and extravagant **Yang Guang (Sui Yang Di)** (580–618; r. 604–18), quickly dissipated the fiscal base Wen Di had built, causing widespread revolts. On Yang Di's assassination, the weakened dynasty collapsed into petty states and was subsequently succeeded by the Tang dynasty.

suicide Suicide is the intentional taking of one's own life. Some forms are direct, such as shooting oneself or slashing one's wrists. Other forms are indirect, such as refusing to take the actions necessary for self-preservation.

During the 19th century social researchers commonly believed suicide to be a "disease of civilization." Anthropologists now believe that suicides occur in virtually all societies, although rates vary considerably. In some cultures, notably Japan, traditional values have encouraged suicide in certain situations. HARA-KIRI was committed to avoid overwhelming shame, such as that following an act of disloyalty or a defeat.

Although some analysts have suggested that certain individuals may be born with a greater tendency to depression and thereby to suicide, all agree that culture, personality, and the individual situation are important factors which help to explain why various societies and subgroups have such widely varying official rates of suicide—for instance, 57.5 suicides per 100,000 persons in Denmark in the mid-1980s compared with only 17.9 in Britain. In the United States, where the rate is 11.5, more men commit suicide than women, and more older people than young people.

Much of the variation in suicide rates can be accounted for by the way the statistics are collected. Another factor is the degree to which a society morally stigmatizes suicide. Roman Catholic nations tend to have low suicide rates largely because the church views suicide as a sin and normally excludes those who kill themselves from Christian burial. This outlook gives everyone concerned—victim, family, friends, and even the clergy—an incentive to make the suicide appear accidental. By contrast, official suicide rates in most Protestant societies are considerably higher.

Types of Suicide

One of the most common types of suicide is the accident suicide. These are deaths that appear to be accidental but that raise questions as to whether the victim intended to die by the act. The death in 1962 of the movie star Marilyn Monroe from an overdose of barbiturates is a well-known example.

Another common form of suicide is the escape suicide. Researchers have found that the suicide notes of such people almost always read as if they believed that they would be able to witness what happened to them after they were dead—because they will be living in a different way or in some other world.

Those who commit revenge suicide intend to make others feel guilty for their deaths. Revenge suicides are also calculated to force outsiders to blame the person "responsible" for the suicide and to feel sympathy for the "victim." This form of revenge apparently works in many cases.

Explanatory Theories

The personality theory attempts to explain suicide on the basis of differences between suicidal people and nonsuicidal people. Motivations are the most frequently cited differences, and the desire to escape depression is the most frequently cited motivation. Disagreement exists, however, on whether the depression of suicides results from events outside them or is organic in origin.

The belief that suicide constitutes a solution suggests another personality factor that may be important: the victim's ideas, beliefs, and ways of thinking. The way people view their problems can produce a greater or lesser tendency to depression and suicide. For example, when things go wrong, some individuals feel more closed in by their immediate circumstances than do others. In short, some people have "basic optimism," others "basic pessimism."

Sociological theories of suicide usually emphasize the importance of either the social structure or the social situations individuals face. The French sociologist Émile DURKHEIM tried to explain the variations in suicide rates among societies as the result of differences in social structure. Thus if a society has values or rules that support suicide, it should have higher rates than a society with values antithetical to suicide.

Because all Western societies have negative attitudes toward suicide, Durkheim argued, it is the structure of rule enforcement that makes all the difference. He tried to show that the more integrated people are in society, the more effective the rule enforcement will be and the less their behavior will deviate from the norm. Unmarried persons without children or friends will be the most likely to commit suicide, Durkheim argued, because no one is likely to be present in their environment to enforce the rules.

The approach taken by a number of recent sociologists, however, lies midway between the psychological and structural approaches. They have attempted to show that suicide can best be explained by looking at the changes that take place in people's situations and the differing interpretations they give to those changes. A particular situation, such as losing one's job, may be caused by general social factors, such as an economic recession that leads to layoffs. The interpretation given to such a situation may be partly a result of personality differences—basic optimism as opposed to basic pessimism—but may also result from complex social interactions among the people involved in the concrete situation. For example, the person who loses a job may see it as merely a temporary setback, but a spouse's blaming that person for the loss may change the situation radically, leading to a suicide motivated by the desire for escape or revenge. Current research and thinking on suicide tend to view biological, psychological, social-structural, and social-situational factors as interacting with each other.

suite

suite The suite is a group of contrasted pieces, mostly in stylized dance forms, for a solo instrument or any combination of instruments up to a full-size orchestra. The term clearly meant different things at different times, and the earliest suites were not even known as such, yet they exhibit similar characteristics to those of later epochs. For example, the pavan-saltarello-piva sequence found in early-16th-century lute music is comparable to the fantasy-almain-galliard form found in English chamber music of the mid-17th century, in that the principle was to offer contrasting tempos and meters within a basically stable key scheme. Occasionally the variegated nature of the movements was unified by a theme, common throughout, yet subject to metrical variation.

Adopted and adapted by composers of various nations, the suite came to be known by other names, such as *parthia* or partita in Germany, *sonata da camera* in Italy, suite of lessons in England, and *ordre* in France.

It was a relatively short step from the orchestral suites of Bach and Telemann to the partitas and cassations of Mozart and Haydn, in which the influence of the dance is still felt. The practice of collecting ballet music in the form of suites found favor in Mozart's day and continued throughout the 19th century and well into the 20th.

Sukarno [soo-kahr'-noh] Sukarno, b. June 6, 1901, d. June 21, 1970, originally named Kusnasosro, was the first president of independent Indonesia. He earned a degree in civil engineering at Bandung Technical College, where he chaired the General Study Club, which evolved by 1928 into the Indonesian Nationalist party.

Exiled and imprisoned several times by the Dutch in the 1930s, Sukarno cooperated with the Japanese following their conquest of the Netherlands East Indies in 1942. He nevertheless maintained contact throughout World War II with the nationalist underground. On Aug. 17, 1945, just after World War II ended, he proclaimed Indonesia's independence.

As president of the new republic, Sukarno initially followed a neutralist foreign policy and hosted (1955) the Afro-Asian Bandung Conference. Later, however, he exhibited a growing authoritarianism, dissolving the elected parliament in 1959 and proclaiming himself president for life in 1963. He also pursued increasingly pro-Communist policies in Indonesia and abroad, and he was implicated in a Communist-instigated attack (Sept. 30, 1965) on the country's top military leaders. General Suharto, who led the anti-Communist counterattack, became president when Sukarno was forced to retire in 1968.

Sukkoth see Tabernacles, Feast of

Sulawesi [soo-luh-way'-see] Sulawesi (also known as Celebes) is a volcanic island in the Greater Sunda Islands in eastern Indonesia. Including the adjacent islands, its area is about 227,650 km^2 (87,900 mi^2), and the population is 12,566,000 (1989 est.). Manado and Makasar are the main cities. The island consists of four fingerlike mountainous peninsulas, with the highest point reaching 3,455 m (11,336 ft). The people, mostly of Malayan origin, raise corn, rice, yams, copra, coffee, and tobacco. Economically, Sulawesi's eastern and southeastern peninsulas are underdeveloped, while the southern and northeastern areas have some recently introduced industries. Deposits of sulfur, iron, nickel, gold, and diamonds are being exploited.

The Portuguese visited the island in 1512. The Dutch established a settlement there in 1607 and gradually assumed control, although indigenous sultans held some areas until 1911. Occupied by Japan during World War II, Sulawesi joined Indonesia in 1949.

Suleiman I, Sultan of the Ottoman Empire (Suleiman the Magnificent) [soo'-lay-mahn] The Ottoman sultan from 1520 to 1566, Suleiman I, known as Suleiman the Magnificent (or the Lawgiver), b. 1494, d. Sept. 5 or 6, 1566, conquered Hungary and Mesopotamia, reformed the legal system, and was a preeminent patron of the arts.

Suleiman succeeded his father, Selim I, who left a throne with unprecedented wealth and power. Suleiman emphasized fair systems of justice and taxation, a balanced budget, and a rational legislative system. The empire reached its height of power and grandeur under his reign, and its arts flourished.

Suleiman concentrated most, however, on military campaigns. He removed the Knights Hospitalers from Rhodes in 1522 and then began his wars against the Habsburgs of Austria. His initial victory over the Hungarian feudal army at the Battle of Mohács (1526) left Hungary, under John I, in vassalage to the sultan. However, the Habsburg archduke Ferdinand (later Holy Roman Emperor Ferdinand I) seized control of part of the territory and defeated John after Suleiman departed for Anatolia. The Ottomans returned, restored John, and moved on to besiege (1529) Vienna. The siege failed, but John's rule was secured, and Suleiman was free to return to the east. After John's death (1540), however, Suleiman occupied Hungary, bringing the Holy Roman Empire and the Ottoman Empire into direct contact. A land stalemate followed, leading to guerrilla war across the frontiers. The conflict then shifted to sea; the powerful new Habsburg fleet and its raids into the central Mediterranean led Suleiman to organize a new navy. Under the command of Barbarossa (Khayr al-Din) it brought Tunisia and Algeria under Ottoman suzerainty and established Ottoman naval predominance in the Mediterranean.

In the east, continued aggression by the Safavids led Suleiman to undertake a series of campaigns into northwestern Iran. In 1535, Suleiman conquered Mesopotamia (Iraq). His dominion over the Arab world complete, he was able to create a powerful eastern fleet with which to safeguard old trade routes and revive the economic prosperity of the Arab provinces.

Suleiman I (the Magnificent) brought the Ottoman Empire to the peak of its power and prosperity. In the west Ottoman armies overran most of Hungary and laid siege (1529) to Vienna; in the east they conquered Mesopotamia. Suleiman was also a notable patron of the arts and a lawgiver

During his later years Suleiman withdrew from active participation in government, and his three sons contested bitterly for the succession. The weakest of these, Selim II (r. 1566–74), succeeded, and the long decline of the Ottoman Empire began.

sulfa drugs Sulfa drugs, or sulfonamides, were the first systemic drugs effectively used to combat bacterial infections in humans. Since the advent of antibiotics, however, their use in therapy has become quite limited. Sulfa drugs are still used, for example, against streptococcal infections, urinary-tract infections, and ulcerative colitis. Drug side effects include reactions in the kidney, liver, skin, and bone marrow.

sulfate minerals The sulfates, a large and varied class of MINERALS, are characterized by the presence of the sulfate ion (SO_4^{2-}) as a major constituent. Because of structural similarities, chromates (CrO_4^{2-}), molybdates (MoO_4^{2-}), and tungstates WO_4^{2-}) are generally grouped with the sulfates. More than 200 sulfate minerals are known; most, however, are rare.

Sulfates occur as primary vein minerals, as secondary minerals (with chromates and molybdates) in the oxidized zone of sulfide ore deposits, or as precipitates in EVAPORITE deposits. GYPSUM, the first mineral to precipitate during the evaporation of seawater, is found in extensive sedimentary deposits, which are frequently mined for use in construction materials and for agriculture. Such deposits in the Paris Basin in France gave rise to the term *plaster of Paris*. The ornamental stone alabaster is a fine-grained, massive variety of gypsum. The chromate crocoite and molybdate wulfenite are rarely abundant enough to mine. The tungstates WOLFRAMITE and scheelite occur as primary vein minerals and are major ores of tungsten.

sulfide minerals Sulfide minerals contain one or more metals in combination with sulfur. Minerals containing semimetals such as arsenic, antimony, or tellurium instead of sulfur have similar properties and can also be classed with the sulfides. Metals found in sulfides include iron, copper, zinc, lead, cobalt, nickel, silver, and mercury. In a large class of sulfides, called sulfosalts, these metals are combined with arsenic, antimony, or bismuth in addition to sulfur.

The sulfide minerals display a great variety of atomic structures and types of atomic bonding; ionic bonds predominate in some, and electron-sharing, or covalent, bonds predominate in others.

Physical Properties

The physical properties of sulfides also vary considerably, but most have a high specific gravity, ranging from 3.5 to 7.5, and most, like GALENA (PbS), are opaque and metallic in luster. Transparent sulfides such as SPHALERITE (ZnS) and CINNABAR (HgS) have brilliant, resinous, or diamondlike lusters. Sulfides come in many colors, depending on their impurities, although yellows and steely to sooty blacks predominate. Most sulfides are relatively soft and can be scratched with a knife. PYRITE (FeS_2), however, can scratch glass.

The several hundred known sulfides differ greatly in abundance. Pyrite, the most common, is one of the most widely distributed of all minerals. Many other sulfides, however, have been found only in a single locality. Sulfides occur in all kinds of igneous and metamorphic rocks and even in meteorites. They are the major ores of many metals, including copper, zinc, lead, silver, and mercury, and important ores of others, such as nickel. Sulfides, especially pyrite, are also found in sediments and sedimentary rocks, where they form in the absence of atmospheric oxygen (anaerobic conditions).

sulfites Sulfites are salts of sulfurous acid (H_2SO_3), but in food science and technology the term also includes sulfur dioxide. The compounds serve as preservatives and antioxidants, as agents against food discoloration, and as sterilizers in wine and beer production. For many years their use was restricted only in meats, because they produce a false appearance of freshness, and in enriched foods, because they adversely affect thiamine. The Food and Drug Administration (FDA) also required labels on finished, packaged foods to indicate the presence of sulfites used as preservatives.

In the 1980s, protests arose over sulfites because they can cause severe, sometimes fatal allergic reactions in some individuals, mainly asthma sufferers; the general population is not at risk. The FDA proposal in 1985 to label all foods containing at least 10 parts per million of sulfites did not provide protection against sulfite treatment of fruits and vegetables in restaurants and supermarkets to maintain their fresh appearance; in 1986 the FDA banned this use of sulfites.

sulfur Sulfur, or sulphur, is a naturally occurring, yellow, water-insoluble solid element. Its chemical symbol is S, its atomic number is 16, and its atomic weight is 32.064. Sulfur is a nonmetal and a member of the oxygen family of elements, which constitutes Group VIA of the PERIODIC TABLE. The discovery of sulfur predates recorded history, and the element has been used since ancient times. The early medical books of Dioscorides of Greece and Pliny the Elder mention sulfur, and fumes from burning sulfur were used in religious ceremonies and for fumigation. Alchemists recognized sulfur as a mineral substance that can be melted and burned. It was first classified as an element by Antoine Lavoisier in 1777.

Occurrence

On Earth, sulfur is widely distributed in its elemental state as a secondary mineral or as a volcanic deposit, as well as in combination with a number of metals. Large sedimentary deposits of the almost pure element, mainly of Tertiary age, are found in the coastal regions of Texas and Louisiana; on the Isthmus of Tehuantepec, Mexico; and in Sicily. Sulfur occurs in some fossil fuels, most notably coal, in chemical combination with carbon and other elements; its removal is difficult. Sulfur is prevalent in the sulfide ores of iron (PYRITE), zinc (SPHALERITE), and lead (GALENA). It also occurs as calcium sulfate (GYPSUM) and barium sulfate (BARITE). The magnesium and sodium sulfates are present in ocean water and in many mineral waters.

Sulfur occurs in living plant and animal tissue as part of the amino acids cysteine, cystine, and methionine. Organic sulfur compounds occur in garlic, mustard, onions, and cabbage and are responsible for the odor of skunks.

Production

Before modern extraction methods were available, sulfur was collected by lowering men in baskets into dormant volcanoes, where the elemental sulfur would be scraped from the vent walls. Today sulfur is obtained from underground sedimentary deposits by a process developed by Herman Frasch (1859–1914). In the Frasch process, a system of concentric pipes is sunk into the earth. One pipe carries superheated water into the deposit in order to melt the sulfur; the molten sulfur is then forced up another pipe to the surface, where it is recovered in nearly pure form. A major source of non-Frasch sulfur is natural gas, which contains hydrogen sulfide, H_2S. Hydrogen sulfide is removed from the gas and converted to sulfur by the Claus process: $2H_2S + O_2 \rightarrow 2S + 2H_2O$.

Increasing quantities of sulfur are extracted from smelter gases arising from the processing of zinc and copper sulfide ores. Sulfur is also extracted from crude oil in the process of refining. Since industries began increasingly burning coal in place of scarce oil, scientists have been developing techniques to recover elemental sulfur from the sulfur dioxide in the stack gases.

Properties of Sulfur

Physical Properties. Sulfur melts at 119° C and boils at 444.6° C. It has six electrons in its outer shell—that is, six valence electrons.

Sulfur occurs in two predominant allotropic crystalline forms, rhombic and monoclinic, which differ from one another only in the manner in which the S_8 molecules pack into the crystal (S_8 denotes a molecule of eight sulfur atoms that form a ring). Below 96° C, only the rhombic form is stable; above this temperature, only the monoclinic form is stable.

Monoclinic sulfur melts at 119° C, forming a pale yellow liquid consisting of S_8 molecules. If the melt is heated above 160° C, the liquid assumes a reddish brown color and becomes extremely viscous. This phenomenon is caused by the breaking of the S_8 rings, with the subsequent formation of chains of up to several thousand atoms in length. Above 250° C, the viscosity of the liquid decreases as the chains begin to break up into smaller units. If molten sulfur at a temperature between 160° and 250° C is suddenly poured into cold water, a rubbery material known as "plastic sulfur" is formed. This material, which consists of long, elastic sulfur chains, is thermodynamically unstable and reverts to rhombic sulfur over a period of several days.

Sulfur has been obtained from volcanic deposits in Sicily for thousands of years. These blocks of sulfur were produced by distilling the sulfur from volcanic rocks and then melting and casting the sublimated product into blocks.

Chemical Properties. Sulfur enters into a variety of chemical reactions displaying a range of oxidation states from −2 to +6. In the reaction of sulfur with alkali metals, sulfur acts as an oxidizing agent: $2Na + S \rightarrow Na_2S$. When sulfur burns in air, according to the reaction $S + O_2 \rightarrow SO_2$, it acts as a reducing agent. Sulfur reacts with fluorine, chlorine, and bromine to yield a number of halides, the most important of which is sulfur hexafluoride, SF_6 (an electrical insulator).

Uses of Sulfur

Modern industrial society is heavily dependent on sulfur. It is used in the commercial production of sulfur dioxide, sulfuric acid, hydrogen sulfide, and carbon disulfide. It is essential in the vulcanization of rubber and in the production of chemicals used in detergents. Elemental sulfur is nontoxic and, in a finely divided form, finds use in ointments for some skin diseases. It is used in making sulfa drugs as well as in the manufacture of insecticides, fungicides, and plant fertilizers.

Sulfuric acid, H_2SO_4, is the most important sulfur compound and one of the largest-volume industrial chemicals. To produce it by the method known as the contact process, sulfur is first burned in air to yield sulfur dioxide, SO_2. The subsequent oxidation of SO_2, to sulfur trioxide, SO_3, is a slow reaction; therefore a catalytic surface made of platinum or vanadium pentoxide is required. Sulfur trioxide reacts with water to yield sulfuric acid; because the direct reaction of SO_3 and water produces a mist of H_2SO_4 that is difficult to condense, the final stage of production takes place in two steps: SO_3 is first dissolved in H_2SO_4 to produce pyrosulfuric acid, $H_2S_2O_7$; then sulfuric acid is produced by the subsequent dilution of $H_2S_2O_7$ with water:

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$
$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

Pure sulfuric acid, a colorless oily liquid, is an extremely powerful dehydrating agent. When concentrated sulfuric acid is added to water, much heat is evolved as the acid ionizes in two steps: $H_2SO_4 \rightarrow H^+ + HSO_4^-$ and $HSO_4^- \rightarrow H^+ + SO_4^-$. Because the first step is complete, sulfuric acid is a strong acid. Hot, concentrated sulfuric acid is an oxidizing agent of sufficient strength to dissolve even such metals as copper. Dilute sulfuric acid behaves as a normal acid (see ACIDS AND BASES).

Large quantities of sulfuric acid are used in the manufacture of fertilizers (superphosphates), paints (titanium dioxide), synthetic fibers (rayons and plastics), detergents (alkylaryl sulfonates), organic chemicals (dyestuffs, explosives, and drugs), and other acids (hydrochloric and hydrofluoric acids). It is also used in lead-acid BATTERIES and in the extraction of alkenes in gasoline refining (see CHEMICAL INDUSTRY).

Sulfur dioxide, SO_2, is a colorless gas with a suffocating odor. This gas is produced by burning sulfur directly and is also obtained as a by-product of the roasting of sulfide ores in the production of zinc and copper. Sulfur dioxide dissolves in water to form sulfurous acid: $SO_2 + H_2O \rightarrow H_2SO_3$; this process occurs in nature through the release of SO_2 into the air from the burning of fossil fuels. Sulfur dioxide and sulfurous acid can damage vegetation, corrode the surfaces of buildings, and injure human lung tissue when inhaled. The gas is used extensively in the production of wood pulp, the bleaching of textiles, and the preservation of fruits and vegetables.

Sodium sulfite, Na_2SO_3, a salt of sulfurous acid, reacts with elemental sulfur to form sodium thiosulfate, $Na_2S_2O_3$. This compound, which is also known as photographer's hypo, is used as a fixing agent in the photographic process.

Several sulfates, or salts of sulfuric acid, have important applications. Magnesium sulfate, $MgSO_4{\cdot}7H_2O$, known as EPSOM SALTS, is used in explosives and matches and in the fireproofing of fabrics. Medicinally, a saturated solution of epsom salts in water is employed as an antiinflammatory agent.

Sodium sulfate, $Na_2SO_4{\cdot}10H_2O$, also known as Glauber's salt, is used in the dyeing and printing of textiles and as a heat storage material in some solar-heated buildings.

sulfuric acid see SULFUR

Sulla, Lucius Cornelius [suhl'-uh] Lucius Cornelius Sulla, *c.*138–78 BC, became dictator of Rome in the chaotic conditions that followed the Social War (90–89) and that pitted this patrician against the popular leader Gaius MARIUS. Elected consul for 88, Sulla obtained the command against MITHRADATES VI of Pontus, but when Marius replaced him in command, Sulla marched on Rome and drove Marius into exile.

Following his defeat (84) of Mithradates, Sulla invaded Italy, where, aided by Marcus Licinius CRASSUS and POMPEY THE GREAT, he finally captured Rome at the Battle of the Colline Gate (82). The bloody massacres and proscriptions of his enemies that followed were legalized by the law making Sulla dictator. He then revised the constitution to make it impossible for outsiders to challenge the powerful families in the Senate who had supported him. After resigning the dictatorship and holding a regular consulship in 80, Sulla retired.

Sulla failed to remedy the social and economic conditions that had undermined the traditional oligarchic republic, and by his usurpations he inspired Pompey and Julius CAESAR to seek the kind of personal preeminence that was incompatible with republicanism.

Sullivan, Sir Arthur Seymour see GILBERT AND SULLIVAN

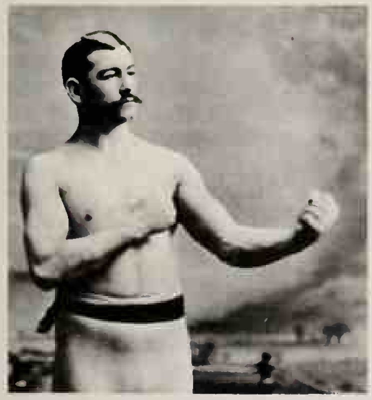
Sullivan, Ed A popular *New York Daily News* columnist and radio emcee (from 1932), Ed Sullivan, b. New York City, Sept. 28, 1902, d. Oct. 13, 1974, became one of the giants of early television after beginning his career as host of a successful CBS variety series, "Toast of the Town," in 1948. Famous for his deadpan facial expression, wooden gestures, and monotone voice, Sullivan nevertheless had a knack for knowing exactly when to present a sensational or newsworthy entertainer, and this ability kept him at the top of the television ratings until his series left the air in 1971. The Beatles, for instance, in 1964 made their first live U.S. appearance on "The Ed Sullivan Show."

Sullivan, Harry Stack The psychiatrist Harry Stack Sullivan, b. Norwich, N.Y., Feb. 21, 1892, d. Jan. 14, 1949, combined Freudian psychoanalytic ideas and social-psychological insights to create the technique of interpersonal psychotherapy. This orientation de-emphasized biology and sexuality in explaining human behavior, stressing instead the influence of personal relationships.

Sullivan made his reputation as a humane and creative therapist with schizophrenic patients at Sheppard and Enoch Pratt Hospital in Maryland. He helped found (1936) the Washington School of Psychiatry, edited the journal *Psychiatry*, and worked on international commissions for peace and mental health. Sullivan contributed to the technique of clinical interviewing and pioneered efforts to understand and help the severely disturbed.

Sullivan, John John Sullivan, b. Somersworth, N.H., Feb. 17, 1740, d. Jan. 23, 1795, was an American lawyer and politician and a general in the American Revolution. After attending the Continental Congress, he served in the siege of Boston. He was captured during the Battle of Long Island (1776) but was exchanged in time to fight at Trenton and Princeton. Sullivan served (1777–78) under Gen. George Washington in New Jersey and Pennsylvania, and in 1779 he fought his most effective campaign, against the Iroquois and Loyalists along the New York frontier. He later served as chief executive of New Hampshire (1786–87, 1789) and as a federal district judge (1789–95).

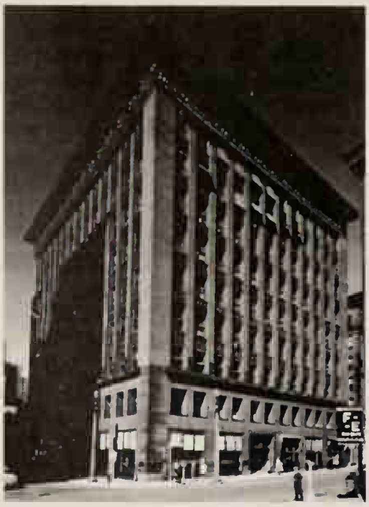
Sullivan, John L. John Lawrence Sullivan, b. Roxbury, Mass., Oct. 15, 1858, d. Feb. 2, 1918, was a legendary American boxer who was the last bare-knuckle world heavyweight champion. Known both as John L. and as the Boston Strong Boy, Sullivan made his professional debut in 1878. He won the London Prize Ring (bare-knuckle) championship when he knocked out Paddy Ryan in the ninth round on Feb. 7, 1882, in Mississippi City, Miss. He made the last bare-knuckle defense of the heavyweight crown on July 8, 1889, knocking out Jake Kilrain in the 75th round. On Sept. 7, 1892, under the Marquis of Queensberry rules, Sullivan attempted to defend his title, but challenger James J. Corbett knocked Sullivan out in the 21st round. During his career Sullivan recorded 31 victories (16 by knockouts), 3 draws, 1 loss, and 1 no-decision. He was inducted into the Boxing Hall of Fame in 1954.



John L. Sullivan was the last world heavyweight boxing champion to fight in the bare-knuckle style. Sullivan successfully defended his title for 10 years, losing it in 1892 at the age of 33.

Sullivan, Louis Louis Henri Sullivan, b. Boston, Sept. 3, 1856, d. Apr. 14, 1924, was one of the founders of the Chicago school of architecture and a key figure in the development of American architecture. As the design partner of the firm he formed (1881) with Dankmar Adler, Sullivan produced several buildings internationally recognized for their functional form, beautiful ornamentation, and significance in the evolution of the SKYSCRAPER. These include the Auditorium Building (1886–89) in Chicago, the Wainwright Building (1890–91) in St. Louis, Mo., the Stock Exchange Building (1893–94) in Chicago, and the Guaranty (now Prudential) Building (1894–95) in Buffalo, N.Y.

While his buildings proudly expressed their urban and functional character in their massing and proportion, the lushly organic ornamentation endows each of the structures with an individual identity. The hollow-cage appearance of the Guaranty Building was humanized and beautified with profuse curvilinear ornament. This successful integration of architectonic and decorative elements profoundly impressed a whole generation of American and European architects.



Louis Sullivan's Wainwright Building (1890–91), St. Louis, Mo., in keeping with Sullivan's dictum "form follows function," reveals the underlying structural frame in its narrow vertical piers and shafts of recessed windows. The crowning frieze and terra-cotta window panels emphasize the verticality of this early skyscraper.

After peaking in the mid-1890s, Sullivan's architectural practice declined precipitously. Following the end of his partnership with Adler in 1895, he found fewer and fewer clients, and most of those were in small midwestern towns. Sullivan blamed this on the eclectic taste fostered by the pompously neoclassical World's Columbian Exposition of 1893—a taste, he predicted accurately, that would last for 50 years. His last great building in Chicago was the sensitively proportioned Schlesinger and Meyer (now Carson, Pirie, Scott) Store (1899; extended 1903–06); such features as extensive glass surfaces and undisguised structural members give it a startlingly modern appearance. Two of his finest late buildings are the National Farmers' Bank (1907–08) in Owatonna, Minn., and the Merchants' National Bank (1914) in Grinnell, Iowa.

Sullivan became, during these later years, an articulate and poetic spokesman for what came to be called organic architecture. While fully accepting contemporary materials and functional needs, he and his Chicago-school followers insisted that American architecture must embody the human connection with nature and the U.S. commitment to democracy. In his *Kindergarten Chats*, first serialized (1901–02) in *Interstate Architect & Builder* and published as a book (1918; repr. 1947), and his *Autobiography of an Idea* (1924; repr. 1956), he castigated prevailing American architectural and cultural practitioners for their failure to respond to the implications of American ideals and modern life. His most famous disciple, Frank Lloyd WRIGHT, published *Genius and the Mobocracy* (1949) as a tribute to Sullivan, who had died in obscurity and poverty in Chicago.

Sullivan Award The James E. Sullivan Award, the most prestigious prize in amateur athletics, is given annually to one athlete in the United States. It is presented by the Amateur Athletic Union (AAU) to the "amateur athlete who, by performance, example, and good influence did the most to advance the cause of good sportsmanship during the year."

The winner is selected and announced in January of each year. More than half of those selected have been track and field athletes, although winners have also come from many other sports. The award was instituted in 1930 and named for James E. Sullivan, former secretary-treasurer of the AAU.

Sully, Maximilien de Béthune, Duc de [sue-lee'] The French statesman Maximilien de Béthune, duc de Sully, b. Dec. 13, 1560, d. Dec. 22, 1641, was a soldier, diplomat, and minister to King HENRY IV. A Protestant, he served Henry (then king of Navarre) during the Wars of Religion (see RELIGION, WARS OF), continuing in his service after Henry converted to Catholicism and became king of France. He entered the council of finance in 1596 and rose to become superintendent. In 1604 he succeeded in converting government offices into semiprivate property for revenue purposes. He fostered the revival of agriculture, issued regulations to encourage trade and manufactures, and developed an authoritarian system of government. His efficient administration produced a budget surplus. Henry IV was assassinated in 1610, and eight months later Sully tendered his resignation. While remaining staunchly Protestant, Sully advised the Huguenots to adopt a moderate policy under Louis XIII.

Sully, Thomas [suh'-lee] Thomas Sully, b. June 8, 1783, d. Nov. 5, 1872, was a leading American portrait painter of the first half of the 19th century. Born in England, he returned in 1809 to study for a year with Benjamin West and the newly fashionable portraitist Thomas Lawrence. In his long career, Sully painted nearly 2,000 portraits and more than 400 other subjects. Among his best-known works is *Washington at the Passage of the Delaware* (1819; Museum of Fine Arts, Boston). The best of his portraits are infused with a romantic spirit, evident in his several portraits of the actress Fanny Kemble and his reflective, full-length portrait of the young Queen Victoria (1838; Society of the Sons of Saint George, Philadelphia).

Sully Prudhomme [sue-lee' prued-uhm'] Sully Prudhomme, pseudonym of René François Armand Prudhomme, b. Mar. 16, 1839, d. Sept. 7, 1907, was a French poet and one of the leading PARNASSIANS. He began publishing poetry in 1865 and in 1866 contributed to the anthology *Le Parnasse contemporain*. Sully Prudhomme's ambitious but mannered poetry resembled that of most of the Parnassians in its attempt to render in verse contemporary philosophy and scientific theories—an antiromanticist notion. His collections include *Les Solitudes* (1869) and *La Justice* (1878). Sully Prudhomme won (1901) the first Nobel Prize for literature.

sultan The word *sultan* (Arabic for "authority" or "domain") originally connoted spiritual authority. First used to mean political authority by Mahmud of Ghazni, a Muslim Afghan ruler of the early 11th century, the title of sultan was conferred on the rulers of the Ottoman Empire and later employed throughout much of the Muslim world.

Sulu Archipelago [soo'-loo] The Sulu Archipelago, which forms the Sulu province of the Philippines, consists of about 400 volcanic and coral islands between Mindanao and Borneo. The population is 317,876 (1980), and the land area is 2,688 km^2 (1,038 mi^2). Jolo, the capital, lies on the largest island, also named Jolo. Rice, cassava, peanuts, coffee, coconuts, and fruits are grown. Fishing and the gathering of pearls, coral, and turtle eggs are also important. The inhabitants, Muslims (called Moros) since the 15th century, were once notorious pirates.

Sulu Sea The Sulu Sea in the western Pacific Ocean is enclosed by Borneo, the Philippine islands of Mindanao, Negros, Palawan, and Panay, and the Sulu Archipelago. Almost 5,600 m (18,400 ft) deep, the sea has an area of about 260,000 km^2 (100,000 mi^2). The sea is fished for turtles, sharks, and pearls.

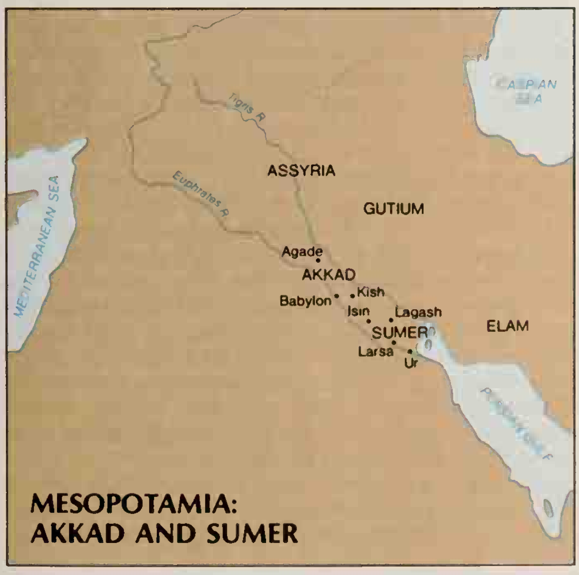
sumac The sumacs are shrubs, vines, or small trees of the genus *Rhus,* family Anacardiaceae. They are usually deciduous, have simple or compound leaves and small, clustered fruits, and grow in temperate and subtropical regions. The poisonous, whitish-fruited members of this genus—including POISON IVY (*R. radicans*), POISON OAK (*R. toxicodendron*), and POISON SUMAC (*R. vernix*)—can cause skin irritation in humans. The red-fruited sumacs include staghorn (*R. typhina*) and smooth (*R. glabra*) sumac, which grow in the United States. Harmless, their fruits are a source of sumac "lemonade."

Sumatra [soo-mah'-truh] Sumatra, an Indonesian island located off the Malay Peninsula, is one of the Greater SUNDA ISLANDS and the sixth largest island in the world, with an area of about 474,000 km^2 (183,000 mi^2). The population numbers 20,361,000 (1989 est.), and the principal cities are MEDAN and PALEMBANG. The volcanic Barisan Mountains rise along the coast to a height of 3,800 m (12,470 ft). Alluvial plains extend from the foothills to the east coast. Because of its hot, wet climate, the island is covered with lush vegetation. Ethnic groups include Batak, Malays, and Minangkabau. Sumatra is Indonesia's richest island; rice, corn, and coffee are grown, and petroleum, tin, iron, coal, and limestone are extracted.

The powerful Srivijaya Empire (7th–13th centuries) was based on Sumatra. The Dutch established settlements in the 1660s and gained sole control of Sumatra in 1824. Japan held the island from 1942 to 1945. Sumatra became part of Indonesia in 1950.

Sumer [soo'-mur] Sumer, an ancient region in southern Mesopotamia located in the extreme southeastern part of what is now Iraq, developed the earliest civilization in the Middle East. The area was virtually devoid of human occupants until about 5000 BC, when settlers moved into the swamps at the head of the Persian Gulf and gradually spread northward up the lower Tigris-Euphrates Valley. The Sumerians, arriving about 3500, presumably came from the east or northeast, although no traces of their unique language or ancestral culture have been discovered outside of Iraq. The Sumerians, who dominated Sumer from about 3100 to about 2100, created many of the basic features of Mesopotamian civilization.

In the Early Dynastic period (3100–2500) BC) a dozen little political units, or city-states, developed in the lower valley, and in the Proto-Imperial period (2500–2350) these states fought one another over land and water rights, with a growing tendency for one unit to conquer others and so create short-lived empires. In the Sargonid period (2350–2200), beginning with Sargon of Akkad, a Semitic-speaking dynasty located in the northern part of the lower valley (Akkad) extended its control over the Sumerians to the south. After the fall of the Sargonids (2200) following an invasion from the north and a subsequent period of some confusion, the Sumerians, led by the kings of the 3d dynasty of Ur (*c.*2150–2000), regained control of Sumer, conquered Akkad, and thus united all of the region later called Babylonia under a single rule. About 2000 BC, however, new invasions coming simultaneously from the west and northeast ended the regime of Ur III, after which the Sumerians lost their identity.



MESOPOTAMIA: AKKAD AND SUMER

Although the Sumerians as a people thus disappeared, their language and literature continued to influence the religion of their successors. Moreover, their basic economic organization, system of writing (cuneiform), architectural forms, and legal practices remained in use, and later generations elaborated upon the mathematics and astronomy that the Sumerians had originated.

Summa Theologiae [suhm'-uh thee-oh-loh'-jee-y] In his *Summa Theologiae* (1267–73) Saint Thomas Aquinas presented a synthesis of Aristotelian logic and Christian theology that was to become the basis of Roman Catholic doctrine on a wide variety of subjects. Thomas divided his work into three parts, the first dealing with the existence and nature of God and the universe he created, the second with human activity and ethics, and the third with Christ and the sacraments. Each part is made up of a series of open questions, in answer to which he presents his opponents' arguments as well as his own before refuting the former. Demonstrated throughout is Thomas's conviction that there can be no contradiction between the truths of faith, based on divine revelation, and those of human reason.

Summerhill Summerhill is a coeducational primary and secondary school, established by A. S. Neill in 1921 in Leiston, Suffolk, England; there students are free to study what they wish or not to study at all. Neill wrote that when children find out for themselves what they need to know they learn much faster and are able to catch up fairly quickly with others. Students are free to do what they want so long as they do not interfere with others' freedom or safety. He measured the success of a school by the happiness of its alumni. Summerhill is governed by an assembly in which each student and teacher has one vote.

summons A summons is a writ, issued by a sheriff or other court officer, requiring a person to appear in court to answer the complaint in an action against that person. In a civil suit the plaintiff's lawyer, as an officer of the court, can prepare the summons and complaint and see that it is delivered to the defendant. Upon receiving the summons and complaint the defendant must draw up an answer. If a defendant ignores the summons, the court will render a judgment against the defendant.

See also: LEGAL PROCEDURE; SUBPOENA; WARRANT.

Sumner, Charles [suhm'-nur] A passionate opponent of slavery, Charles Sumner, b. Boston, Jan. 6, 1811,

d. Mar. 11, 1874, was a pivotal figure during the Civil War and Reconstruction periods of U.S. history. He joined the antislavery movement in 1845, becoming a leader of the "Conscience Whigs." An active organizer of the Free-Soil movement of 1848, Sumner was elected to the U.S. Senate in 1851. He helped organize the Republican party in 1854–55 and was one of the most eloquent opponents of slavery in Washington, D.C. Once, a few days after a powerful speech, he was viciously attacked and beaten by a Southern congressman, Preston Brooks, in the nearly empty Senate chamber. Severely injured, he could not return to his Senate seat for three years.

Returning to the Senate in 1859, Sumner became (1861) chairman of the prestigious Foreign Relations Committee during the Civil War and fought for the abolition of slavery. When the war ended, he insisted that equal political and civil rights be guaranteed to the former slaves as part of any reconstruction plan. Opposing all compromises that fell short of that requirement, Sumner helped force the break between President Andrew Johnson and congressional Republicans. Although Congress's final program fell short of his ideal, it did incorporate civil and political equality.

During Ulysses S. Grant's administration Sumner broke with the president over foreign policy. As a result, Senate Republicans removed him from his committee chairmanship. In opposing Grant's reelection in 1872, Sumner lost all influence in the Senate, although he remained popular among the Republican rank and file until his death.

Sumner, William Graham William Graham Sumner, b. Paterson, N.J., Oct. 30, 1840, d. Apr. 12, 1910, was a sociologist, economist, and Episcopal minister. As a Yale University professor (1872–1909), Sumner introduced the classic concepts of folkways and mores in *Folkways* (1906). Sumner adamantly opposed any aid to the poor, espousing an extreme form of Social Darwinism, the philosophy of the survival of the fittest in society.

sumo see wrestling

sumptuary laws Sumptuary laws, from the Latin *sumptus* (expense), were originally laws against luxury and extravagance. They served to maintain moral standards and distinctions between social classes. Such laws existed in China under the Zhou dynasty (*c.*1027–256 BC) and in medieval Japan. In the West they were prevalent in Roman and late medieval times and during the Reformation. In republican Rome, such laws as the Oppian law (215 BC) and the Didian law (143 BC) regulated dress and entertainment. In the late Middle Ages most European states passed sumptuary laws. For example, the French king Philip IV instituted (1294) laws decreeing that no commoner could wear fur, precious stones, or gold; that no duke, count, or baron could have more than four robes a year; and that no one who gave a dinner could serve more than two courses besides the soup. During the Reformation, additional sumptuary laws were passed in Switzerland, Italy, France, and England. Later, Puritan New England also had sumptuary legislation. As a rule, however, these later laws were sporadically enforced and not long retained.

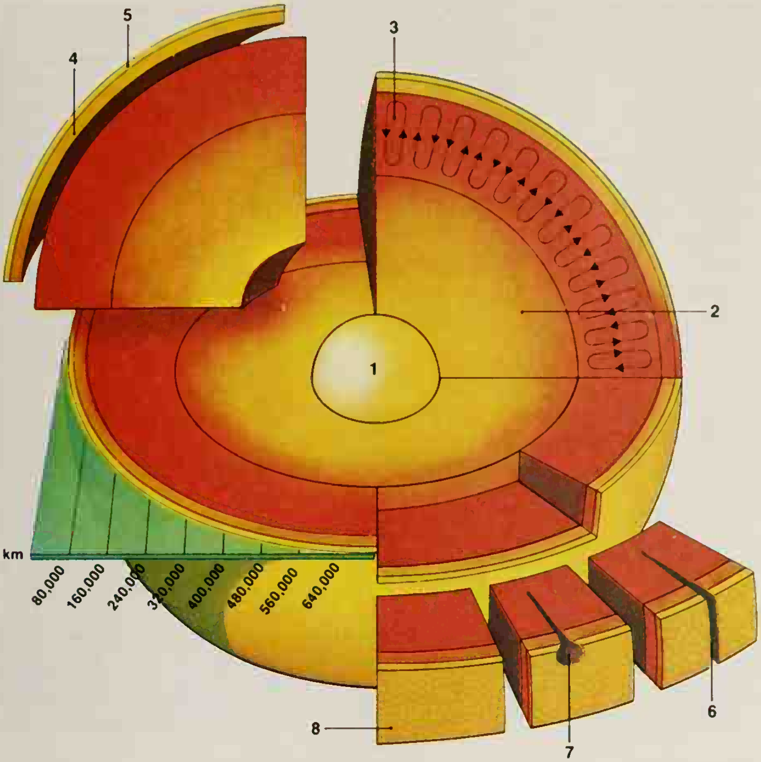
Sumter, Fort see Fort Sumter

Sumter, Thomas Known as the "gamecock of the Revolution," Thomas Sumter, b. Hanover County, Va., Aug. 14, 1734, d. June 1, 1832, led rebel guerrilla forces during the American Revolution. When the British won control of South Carolina in 1780, he, Francis Marion, and other partisan fighters kept the rebel cause alive south of Virginia until the victory at Yorktown a year later. After the war he represented South Carolina as a U.S. representative (1789–93, 1797–1801) and senator (1801–09). Fort Sumter in Charleston was named in his honor.

Sun The Sun, the central body of the solar system and the closest star, is an immense sphere of glowing gas 1.39 million km (860,000 mi) in diameter at an average distance from the Earth of 149,591,000 km (92,960,000 mi). It is composed mainly of hydrogen, with about 5 percent by number of helium and heavier elements. Its mass of 1.99×10^{33} g is sufficient for the mutual gravitational attraction of the molecules to prevent the hot solar gases from expanding rapidly into the relative vacuum of interstellar space. The Sun generates energy at the rate of 3.9×10^{33} ergs/sec by burning hydrogen to helium through nuclear fusion reactions in its interior. This energy is radiated into space mostly in visible and infrared light and is largely responsible for the continuation of life on Earth.

Compared with the largest known stars, with diameters a thousand times larger and masses several hundred times greater, the Sun merits its astronomical designation as a dwarf star. Its mass and radius are close to the average mass and size of all stars in the Galaxy, however, because many stars are even smaller and less massive than ours. The Sun's spectrum, surface temperature, and color lead to its further classification as a G2 dwarf in the scheme of spectral types used by astronomers. The spectral intensity of light radiated by its surface gases is a maximum at wavelengths near 5000 Å, thus giving sunlight its characteristic yellow color.

Modern study of the Sun began in 1611 with Galileo's observations of sunspots and his discovery of solar rotation from their motions. The first approximately correct determination of the Sun's size and distance from the Earth was made in 1684, from data obtained by the French Academy from triangulation observations of Mars during its close approach to the Earth in 1672. The discovery of the solar absorption-line spectrum by Joseph von Fraunhofer in 1814, and its physical interpretation by Gustav Kirchhoff in 1859, opened the era of solar as-



The Sun's energy is produced by nuclear fusion in the central core (1). *The energy is transported mainly by radiation in the surrounding region* (2) *and then by circulating currents of gas in the convection zone* (3), *a 150,000-km-thick (93,000-mi) region just below the visible surface, or photosphere* (4). *The photosphere in turn is surrounded by the chromosphere* (5). *Features such as a dark filament (6) or sunspot* (7) *may appear on the granular textured* (8) *solar surface.*

trophysics, during which the effective study of the physical state and chemical composition of the solar material became possible. The strong magnetic fields of sunspots were detected by George Ellery Hale in 1908, and the role of nuclear fusion in producing solar energy was elucidated by Hans Bethe in 1939. Modern developments continue to change scientists' perception of the Sun. The SOLAR WIND was not detected directly until 1962, and the sources of its high-speed recurrent streams awaited the observations of coronal holes in 1969.

Structure of the Sun

From its innermost core to its corona, and to the solar wind that extends even to the Earth, the Sun has a structure typical of most stars of its kind.

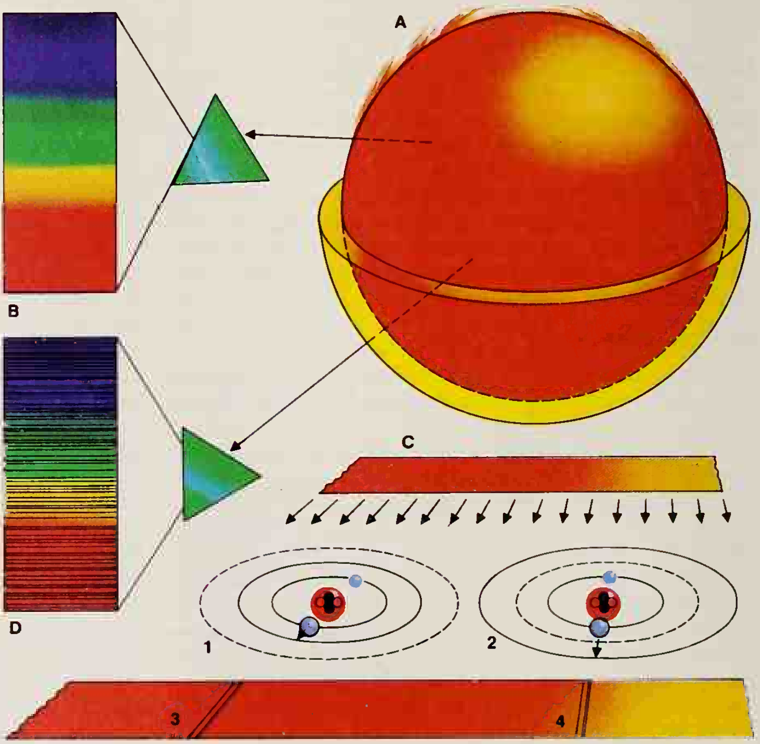
Inner Core. The weight of the Sun's outer layers compresses the gas of the innermost region to a density about 100 times that of water and raises the central temperature to about 15 million K (27,000,000° F). Throughout the Sun's interior, atoms collide frequently and with enough energy to ionize the gas, which is then referred to as a plasma (see PLASMA PHYSICS). In the inner third of the Sun the collisions among ions are energetic enough to cause nuclear reactions at a rate sufficient to liberate the energy required to give the Sun's observed luminosity. The specific set of reactions thought to be most effective in generating energy in the Sun involves the burning of hydrogen to helium, following the specific sequence of reactions known as the proton-proton reaction. Present evidence suggests that the plasma of the central nuclear burning region of the Sun is not mixed with the material in the outer shells. Thus the proton-proton reaction will continue only until the hydrogen of the central region, some 10 percent of the Sun's mass, becomes transformed into helium after about 10 billion years. The Sun's age is estimated to be about 5 billion years (see STELLAR EVOLUTION). The gamma rays and X rays emitted by the nuclear reactions travel outward with little absorption through the solar interior, because the electrons that allow an atom to absorb light have mostly been stripped from the nuclei by interatomic collisions.

The Convection Zone and the Photosphere. Nearer the Sun's visible surface, as the weight of overlying gas diminishes, the gas pressure and thus the density and temperature required to support this layer in hydrostatic equilibrium decrease rapidly. At a distance of about two-thirds the solar radius from the center, where the temperature has dropped to about 1 million K, the hydrogen and helium are no longer completely ionized. The neutral atoms absorb radiation moving outward from the central nuclear burning regions. In this region the heating and consequent expansion of parcels of the fluid cause them to rise because of their lower densities, and transport their heat upward. The net upward flux of heat carried by the resulting pattern of up- and down-flowing convection is the dominant mode of energy transport in the outer third of the Sun. Convection continues to be efficient in transporting heat until layers are reached where the density is so low that radiation from the hot up-flowing gas can escape directly into space. This layer is the visible surface of the Sun, known as the photosphere. Direct evidence for the size scales, velocities, and shapes of solar convective scales can be deduced from observations of convectionlike cellular motions at the photosphere. Small-scale cells called granules are about 1,000 km (620 mi) in diameter and are formed by hot up-flowing gases, surrounded by cooler down-flowing gases, moving about 1 km/sec (about 2,200 mph). Supergranules form a larger set of polygonal cells, of diameter roughly 30,000 km (18,600 mi), detected by their horizontal velocities of about 0.5 km/sec (about 1,100 mph).

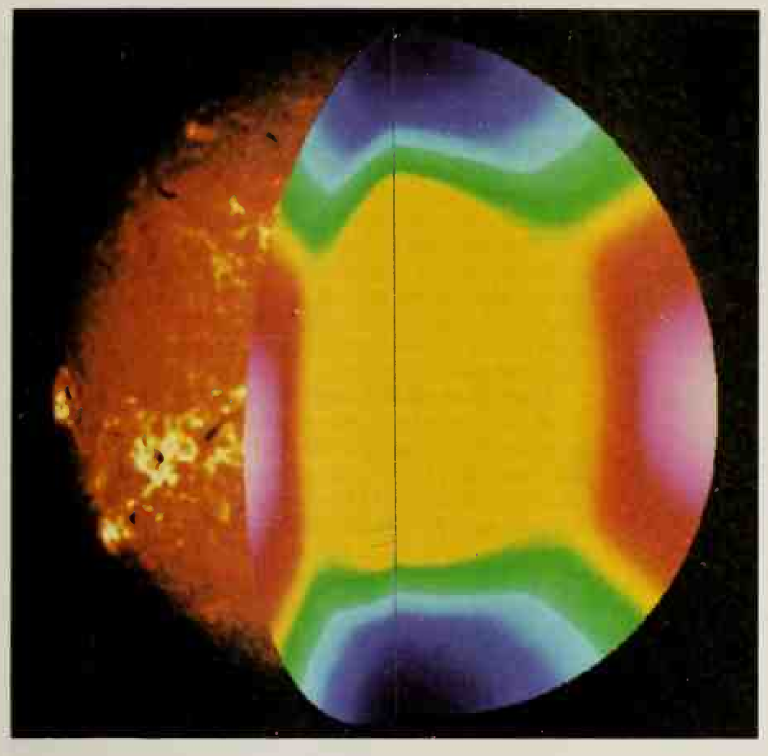
In addition to transporting heat, convective motions of the Sun's gases are also thought to have important consequences for solar rotation, solar magnetism, and for the structure of the Sun's outer layers above the photosphere. Convection may help to explain the observation that the gases of the solar photosphere do not rotate rigidly—the angular rate at the equator is some 50 percent higher than that at latitudes of ±75 degrees. Although a satisfactory theory of this basic solar property does not yet exist, models of the fluid mechanics of rotating, convecting shells indicate that such velocity differences might result from the forces exerted upon rising and falling convecting gases as the Sun rotates about its axis at the observed sidereal rate of about 25 days at the solar equator.

A spectrogram of the solar light shows a bright background continuum traversed by many dark absorption lines. The continuum radiation that is visible to the eye, roughly between 4000 Å and 7000 Å, is emitted when electrons released from the relatively easily ionized heavy elements are captured by neutral hydrogen atoms. The dark Fraunhofer lines, such as the H and K lines of ionized calcium, are formed when light of certain discrete wavelengths is preferentially scattered by the particular species of neutral atoms or ions that are abundant at the density and temperature of the photosphere. The light emerging through the photosphere at these wavelengths is changed in frequency by multiple scattering of the photons from atoms and rapidly moving electrons, and is emitted instead in the continuum.

The Chromosphere. Above the photosphere, the temperature drops to a minimum of about 4,500 K, and then, remarkably enough, begins to rise. During a few seconds around totality during a solar eclipse, a thin ring (annulus) about 10,000 km (6,200 mi) thick around the limb is seen shining with a reddish glow, leading to its designation as the chromosphere ("color sphere"). Upon examination with a telescope and spectrograph at high resolution, most of the chromospheric emission is seen to come from very fine jets of outward-



The light energy produced in the interior of the Sun (A), *if seen unobstructed, would produce a continuous spectrum* (B; detail, C) *when analyzed by a spectroscope. As the light passes through the outer layers of the Sun, however, it excites some of the electrons orbiting around the nuclei of, for example, helium atoms, lifting them to various higher energy states* (1, 2). *The consequent absorption of energy produces characteristic dark absorption, or Fraunhofer, lines* (3, 4) *in the spectrum. An actual solar spectrum* (D) *is therefore crossed by many lines characteristic of each of the elements present in the Sun.*



(Left) *The Sun has varying interior rotation rates. The rates range from 35 days (deepest blue) to 25 days (violet). The core rotates as a solid body with a period of about 27 days.* (Above) *An eruptive prominence—a hot, bright cloud of gas—is seen in a* Skylab *photograph taken in the far ultraviolet.*

moving gas called spicules, at a temperature of about 15,000 K and a density of some 10^{11} particles/cm^3. A spicule lasts some 5 to 10 minutes and is typically 6,000 km (3,700 mi) high and perhaps one-tenth as thick. The gases are moving outward at speeds of about 10 km/sec (22,000 mph).

The Corona. During a total solar eclipse, or with a coronagraph, the Sun's atmosphere can be seen extending to several solar radii beyond the photospheric limb as a faint glow, about one million times less bright than the disk. The height of the corona was for some time puzzling to scientists, because it seemed that the density should drop off so rapidly that no corona would be visible at distances of even a small fraction of solar radius above the limb. The explanation for this discrepancy came in 1940 when certain unidentified lines seen in the spectrum of the corona were demonstrated as arising from transitions in iron ionized up to 13 times, implying temperatures of several million K. Because a hot gas is expected to be compressed relatively less by the weight of overlying layers than a cool one, the high coronal temperature explained why the corona remains visible much farther above the limb than might be expected.

The specific mechanism that heats the corona to such a high temperature is still unclear, and this question is the focus of much of modern solar research from satellites. The coronal gas close to the Sun is visible with the naked eye during eclipses because it scatters photospheric light from electrons in the plasma. The hot coronal plasma also emits its own ultraviolet and X-ray light when rapidly moving electrons collide with ions of the heavier elements. For instance, the lines of 9-times-ionized magnesium and 11-times-ionized silicon are prominent in the ultraviolet spectrum. The heating of the corona is not a matter of simple heat flow from the cooler photosphere, by either conduction, convection, or radiation, because such a heat flow would violate the second law of thermodynamics. Most likely, acoustic or other forms of waves generated by gas motions at the photosphere may carry energy into the coronal medium and dissipate it into heat, balancing the corona's losses. Another alternative is dissipation of electric currents in the highly conducting coronal plasma, in much the same way that joule heating raises the temperature of a common resistor.

Solar Activity

The intense magnetic fields produced in the solar interior influence the physical structure of the photosphere, chromosphere, and corona in a complex and time-varying way described collectively as solar activity.

Sunspots, Faculae, and Flares. The magnetic fields emerge at the visible layers as toroidal loops of magnetic flux up to 100,000 km (62,000 mi) in diameter. Their most obvious effect at the photosphere is to produce the dark SUNSPOTS and bright faculae that constitute an active region. If, as believed, the intense radially directed fields inhibit convection, and thus reduce the efficiency of the dominant heat-transport process to the photosphere, the low temperature and relative darkness of sunspots would be explained. How intense fields can also produce a net facular brightening under similar circumstances is still unclear.

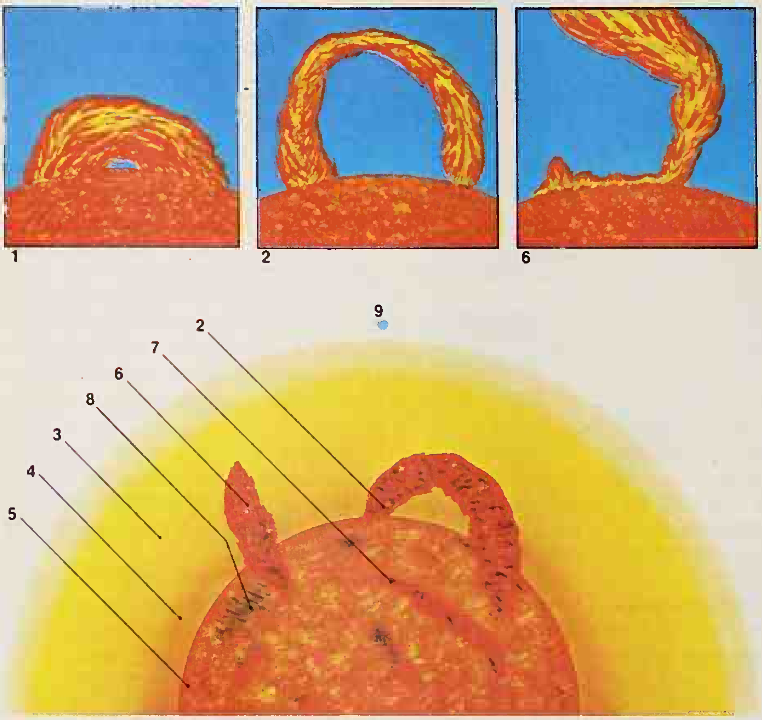
An active region grows in horizontal extent as the loop emerges, from less than 5,000 km (3,100 mi) across, to more than 100,000 km (62,100 mi) within 10 days. During this period of rapid growth the probability of a spectacular eruption, called a solar flare, is highest. A large flare is marked by a rapid brightening within a few minutes of a considerable area of the active region by a factor of 5 to 10, as seen in chromospheric radiations such as the H alpha line of hydrogen. Only the very largest flares can be detected in integrated white light against the bright photosphere. The most violent and spectacular effects of the eruption, however, take place in the corona above. Here, a set of the magnetic loops above the spots and faculae may increase their brightness in X-ray and ultraviolet light by a factor of 100 or more. Charged particles are accelerated to relativistic energies, and strong centimeter-wave emission is generally detected.

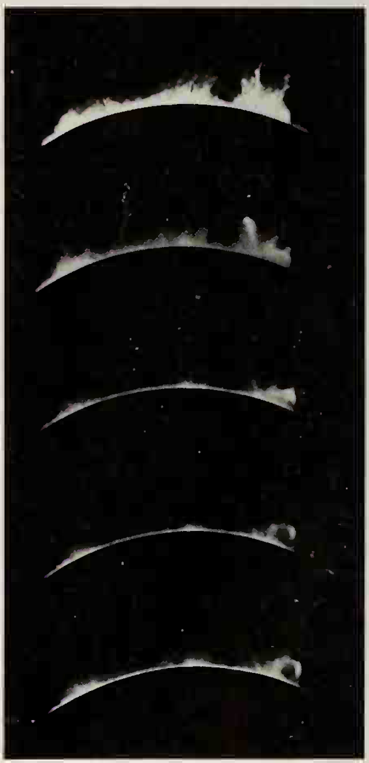
Sunspots generally last a few weeks, with the most persistent large spots surviving for 2 to 3 months. The faculae continue to mark an active region for somewhat longer. Eventually, it appears that the random motions of convection near the photosphere disassemble the magnetic flux loop and disperse it into smaller elements distributed over the surface.

Away from the active regions, less extended fields of comparable intensity (1,000 to 2,000 gauss) are measured, but they are confined to a polygonal network that coincides with the edges of the supergranular convective cells mentioned above.

Loops, Prominences, and Coronal Holes. Above the photosphere the magnetic fields over an active region can be seen by their effect on the distribution of temperature and density in the chromosphere and corona. Here, prominent loop-shaped structures seen in X rays and ultraviolet light show how the field lines extend to 100,000

(Below) *Quiescent* (1) *and loop* (2) *prominences are formed when material condensing in the corona* (3) *falls back through the chromosphere* (4) *to the photosphere* (5), *or surface, of the sun along lines of magnetic flux. An eruptive prominence* (6), *on the other hand, consists of material that has been ejected above the photosphere to distances as great as 300,000 km (190,000 mi). An explosive release of energy occurs in a solar flare* (7), *which appears as a brilliant flash of light in the upper chromosphere and the lower corona. Spicules* (8) *are small, vertical, jetlike spikes of gas in the chromosphere that rise and subside for several minutes. The Earth* (9) *is dwarfed when compared in size to these solar features.*





(Above) *This sequence of photographs, taken over a period of several hours, reveals the dynamic nature of prominence activity above the Sun's surface. Prominences are luminous clouds of gas in the Sun's corona.*

km (62,000 mi) or more above a spot, and then connect back to the photosphere, generally within the same extended patch of activity. In other regions of the corona immense sheets of relatively cool (10,000 K as opposed to the 1 to 3 million K of the corona) condensed plasma, called prominences, are supported at heights up to 200,000 km (124,000 mi).

In certain large areas, called coronal holes, the coronal emission is significantly depressed, indicating a low density of the million-degree plasma. Studies indicate that in these regions the field lines continue radially outward and do not form closed structures, as in loops or prominences. Models show that the hot corona can then flow out into interplanetary space more easily, leaving a deficit of coronal material. Such holes are particularly common at the solar poles, where no active regions with closed fields are observed.

Solar Activity Cycle. Solar activity exhibits a cycle over a period of about 22 years, the most easily observed feature of which is the approximately 11-year variation in the number of sunspots. At the beginning of a new cycle, the first groups emerge at latitudes between 35 and 40 degrees; their magnetic polarity is opposite to that of the last groups of the preceding cycle in the hemisphere concerned. Thus two consecutive 11-year cycles are required to return to a given level of spot number and a given polarity. This pattern is further complicated by observations of more ephemeral, spot-free magnetic regions, atmospheric currents, and bright coronal patches, all of whose cyclical patterns suggest that the 22-year cycles may in fact overlap. Theorists have proposed that eddies forming near the poles in the solar convection zone and moving equatorward may underlie the cycles.

The 22-year cycle seems to have been fairly regular over the past century and longer, but historical evidence indicates that between about 1640 and 1710—the so-called Maunder Minimum—hardly any spots were visible at all. Scientists drilling into Australian lake-bed deposits dating from 680 million years ago, however, have found evidence of a period of sunspot cycles that persisted unbroken for 19,000 years, suggesting that such periods as the Maunder Minimum are simply anomalies that await explanation.

Long-term irregularities in solar activity are of practical interest because solar fluxes of charged particles and ultraviolet radiation are directly controlled by the level of activity through active regions, flares, and coronal holes. Variations in these emissions are known to affect the upper atmosphere and may also have important influences on climate.

Recent Developments

The Sun still holds many mysteries. For example, the proton-proton reaction thought to be the source of most solar energy should also produce a certain number of the particles called NEUTRINOS, yet studies thus far have detected significantly fewer neutrinos than theory predicts. One radical suggestion is that the Sun produces fewer neutrinos than expected because it has an iron-plasma core that amounts to about 0.5 percent of its total mass. Other physicists have theorized that weakly interacting massive particles (WIMPs)—predicted by GRAND UNIFICATION THEORIES and sometimes invoked to account for the "missing matter" in the universe—might exist deep within the Sun and lower its temperature enough to explain the lack of neutrinos. Yet another proposal is that electron-type neutrinos in the Sun's core change on the way out into muon-type neutrinos unobservable by the detectors now in use.

The corona, or outermost portion of the Sun's atmosphere, can be seen during a solar eclipse, such as the one that occurred on Mar. 7, 1970.

In the early 1960s, radial oscillations of the photosphere were detected that have since been explained as the resonant trapping of acoustic waves between certain layers of the convection zone of the Sun; the WIMP theory helps to explain some details of the oscillations, as well. Close studies of these oscillations are enabling scientists to probe the density, temperature, and velocity patterns of the invisible subphotospheric layers. Scientists have also observed that the Sun's diameter fluctuates by about 0.01 percent of the average diameter over a nearly 80-year cycle, and longer-period pulsations may be possible.

Sun Also Rises, The Ernest HEMINGWAY's first novel, *The Sun Also Rises* (1926), is a semiautobiographical account of the adventures of a group of expatriates, members of the so-called lost generation, in France and Spain in 1925. They are led by Jake Barnes, a journalist. Although a war wound has made Jake impotent, he and Robert Cohn, another American romantic, are rivals for the attentions of Lady Brett Ashley. The action moves from Paris to Pamplona and the fiesta of San Fermín, where the real hero, a bullfighter named Pedro Romero, conquers several bulls as well as Lady Brett, who nobly rejects her Spanish lover and returns hopelessly to Jake.

sun bittern The sun bittern, *Eurypyga helias*, the only member of the family Eurypygidae, is a bird that inhabits tropical forests of Central and South America. Bitterns live alone or in pairs; they feed on insects, crustaceans, and small fish. The soft plumage is mottled with black, gray, white, and brown. Black bands cross the fan-shaped tail, and the long and broadly rounded wings have bold patterns of black, gray, white, and chestnut. White stripes are prominent above and below the eyes. The long legs are orange, and the bill is long and straight. Sun bitterns are about 41 cm (16 in) in length and weigh approximately 220 g (8 oz), both sexes being alike in size. The nest of mud and sticks is built on the ground or in a low bush or tree. Both sexes incubate the two or three eggs.

Sun dance The Sun dance, a traditional summer ceremony of the Plains Indians, was most highly elaborated among the ARAPAHO, CHEYENNE, and SIOUX (Dakota) and was present in some of its elements among the OMAHA, PAWNEE, and WICHITA. Physical pain was used to induce altered states of consciousness and a sense of exaltation. The means of accomplishing these goals were fasting, dancing for 3 or 4 days and nights, keeping eyes fixed on the Sun or a sacred object at the top of a pole, and dragging a heavy buffalo skull attached to skewers piercing the celebrant's flesh. Lapsed for a time because of government disapproval, the ritual has been revived since the 1960s as a way of preserving Indian identity and culture.

Sun Valley Sun Valley (1990 pop., 938), a popular resort center in south central Idaho, lies 1,829 m (6,000 ft) above sea level, sheltered to the west and east by the Sawtooth Range of the Rockies. The development of its skiing and summer sports facilities was begun in 1936 by the Union Pacific Railroad.

Sun worship Worship of the Sun occurred among many ancient peoples, especially in agrarian societies, in which survival depended on the light and heat of the Sun to bring crops to fruition. The daily journey of the Sun across the sky and its nightly disappearance and morning resurrection, as well as the occurrence of solar eclipses, formed a mystery that inspired various religious feelings among ancient peoples, who developed ceremonies, rituals, and sacrifices to honor and placate this life-force. The Sun appears as an element of religion and mythology in cultures as divergent as those of India, Africa, Mesopotamia, Greece, Britain, and Aztec Mexico and among many Indian tribes of North America. Among the ancient Egyptians, Amon-Re, the sun-god, was regarded as the first king of Egypt.

Sun Yat-sen [suhn yaht-sen] Sun Yat-sen, b. Nov. 12, 1866, d. Mar. 12, 1925, was the symbol and leader of the Chinese nationalist revolution and the first president of the republic that succeeded the Manchu, or QING, dynasty in 1911. He is one of modern China's most revered political figures.

Born Sun Wen in Xiangshan, Guangdong province, the future father of the republic endured the hardships of peasant life as a boy and, fired by stories of the heroic Taiping Rebellion, resolved to carry on the fight begun by the Taiping to overthrow the alien Manchu rulers. After three years at a Christian school in Hawaii, Sun studied medicine in Guangzhou (Canton) and Hong Kong. In 1895, Sun, now an active revolutionary, was forced to flee China when a plot by his Xing Zhonghui (Revive China Society) went awry. Visits (1896) to the United States and England and his "kidnapping" by the Chinese legation in London brought him worldwide publicity.

In Japan Sun founded (1905) the Tongmenghui (Alliance Society), with overseas offices, and issued (1907) a manifesto that contained an early version of his Three Principles of the People (Sanmin Chui)—roughly translatable as nationalism, democracy, and the people's livelihood. Sun continued to publicize his revolutionary theories and to raise money from overseas supporters. When revolution finally erupted in 1911, Sun was named provisional president. In 1912 he resigned the presidency of the new republic in favor of YUAN SHIKAI, whose power was needed if the republic were to survive. As the dictatorial policies and imperial ambitions of Yuan became clearer, however, Sun's colleague Song Jiaoren organized the KUOMINTANG (National People's party), which twice (1917 and 1921) set up a rival government in Guangzhou. Sun's last years were spent as an elder statesman.

The Chinese revolutionary leader Sun Yat-sen played a central role in the overthrow of the Qing dynasty and was named (1911) provisional president of the new Republic of China. To unify the country he agreed (1912) to turn over authority to Yuan Shikai, but the latter's dictatorial methods soon drove Sun into opposition.

Sunda Islands The Sunda Islands of Indonesia lie between the Malay Peninsula and New Guinea, separating the Pacific from the Indian Ocean. The islands are divided into the Greater Sundas (Borneo, Java, Sulawesi, Sumatra) and the Lesser Sundas (Bali, Timor, and others).

Sunda Strait The Sunda Strait is a major shipping lane between the Greater Sunda islands of Sumatra and Java. It links the Indian Ocean and the Java Sea and is about 26 km (16 mi) wide at its narrowest point. Krakatoa, noted for its major volcanic eruption, lies in the strait.

Sundanese language see MALAYO-POLYNESIAN LANGUAGES

Sunday, Billy William Ashley Sunday, b. Ames, Iowa, Nov. 19, 1862, d. Nov. 6, 1935, was a professional baseball player who became one of the most popular revivalists in American history. He played (1883–91) for the Chicago White Stockings before a conversion experience led him into YMCA work. After ordination as a Presbyterian minister, he began (1895) his career as a revivalist. He had a flamboyant style characterized by acrobatics and high-pressure techniques. His peak years of success were during the World War I period. Sunday was influential in the PROHIBITION movement and was associated with nativist movements calling for the Americanization of immigrants and restriction of immigration.

Sunday school A Sunday school is a school for religious education, usually of children and young people. It is most often associated with a particular church or parish.

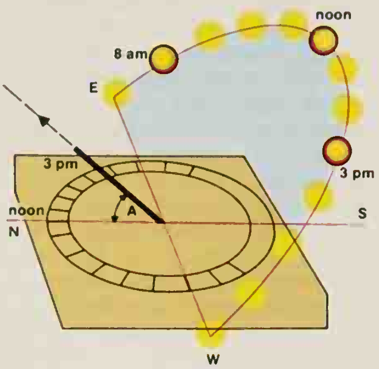
The first modern Sunday school was established in Gloucester, England, in 1780, by Robert Raikes. His work among prisoners convinced him that religious education would help keep young people out of jail. Because so many children worked in factories every day except Sunday, he formed a school that met on Sundays in the homes of lay teachers. The movement spread rapidly in England and Wales and was introduced in 1791 in the United States. It was less important in Europe where religious education was part of the school curriculum.

Sunday schools are usually associated with Protestant churches, although in the United States many Roman Catholic churches have them.

sundew see CARNIVOROUS PLANTS

sundial The sundial, one of the earliest scientific instruments known, measures the time by a shadow cast from an indicator onto a surface that is marked off in time intervals. Examples from Egypt dating from the 15th century BC and numerous large dials from early Greek cities can be seen in museums today. Small portable dials for personal use first appeared in Roman times and remained popular well into the 19th century.

The most common form of sundial measures the hour-angle of the Sun. Almost all garden dials are of this type. The rod or bar that casts the shadow is called the gnomon and is mounted so as to be parallel with the axis of the Earth. Hour-angle dials show solar time correctly throughout the year without the necessity of adjusting them to a specific date. (A chart or table is often provided with these dials to convert true solar time to mean solar, or "clock," time.)



A sundial uses the changing position of a shadow to indicate the time of day. A raised pointer, or gnomon, is fixed to a horizontal plate at an angle equal to the latitude of the site, pointing north (angle A). *The plate is marked off in hourly segments. As the Sun passes from east to west, the shadow of the gnomon moves through the divisions, indicating the hour.*

sunfish Sunfishes comprise 30 species of freshwater, spiny-rayed teleosts (bony fishes) of the family Centrarchidae found in North America. The larger sunfishes are solitary, and all sunfishes are very sensitive to changes in their environment, particularly temperature changes. The Sacramento perch is the only native American species west of the Rocky Mountains and the only species that does not nest.

The genus *Lepomis* is the largest group of sunfishes. Most are small, from 8 to 25 cm (3 to 10 in). The most familiar species is the bluegill sunfish, *L. macrochirus*, which is known to reach a weight of 1.75 kg (4.75 lb). Other species familiar to anglers include the redear, pumpkinseed, and longeared sunfishes. *Lepomis* species

The pygmy sunfish (foreground) *and the black-banded sunfish* (background) *are bred as aquarium fish.*

prefer the shallow, weedy margins of lakes and streams. Like all centrarchids, the male builds a breeding nest and entices a female to the nest, where she lays a number of eggs. After the male has fertilized the eggs he chases the female away and guards the nest against any intruder until they hatch. *Lepomis* is frequently stocked in ponds and lakes with largemouth bass to provide forage for the bass and fishing for the angler.

Pygmy, or blue-spotted, sunfishes, *Enneacanthus gloriosus*, are from the eastern and southern United States and reach about 9 cm (3.5 in) in length. The dwarf sunfishes (genus *Elassoma*), which include three known species from the southern United States, reach only 4 cm (1.5 in) in length and are primarily inhabitants of swamps and backwaters. Their relationship to other sunfishes is a subject of controversy. Centrarchids are not closely related to the OCEAN SUNFISH (*Mola mola*) found throughout the world in warm seas.

sunflower Sunflowers, genus *Helianthus*, are any of 60 New World plant species in the daisy family, Compositae. Primarily native to North America, they are annuals or perennials with large and colorful heads of yellow flowers. The common sunflower, *H. annuus*, is cultivated for its edible seeds, which are used as food for poultry and birds and for vegetable oil and oleomargarine. The roots of *H. tuberosus* comprise the inulin-rich Jerusalem artichoke, which is eaten as a vegetable and often pickled. These plants are propagated by their tubers. The globe artichoke that humans consume is a large flower head, not a tuber; it belongs to a different genus.

Sung see SONG

Sung Hui-tsung see SONG HUIZONG

sunlamp A sunlamp, consisting of a fluorescent tube and a mercury vapor lamp, produces a spectrum of radiation that is similar to that of the Sun. As a result, even though a sunlamp can be used for therapeutic purposes or for artificially inducing a skin tan, it should be used with caution. Sunlight, both artificial and natural, damages the skin, causes it to age prematurely, and is toxic in extreme doses. Skin cancers show an increased incidence in skin overexposed to sunlight. Most sunlamps do not produce light across the complete spectrum and therefore are less harmful than natural sunlight; the strong ultraviolet component in all of them, however, makes irritation of the eyes a serious risk, and eye protection has to be worn to filter out the harmful bands.

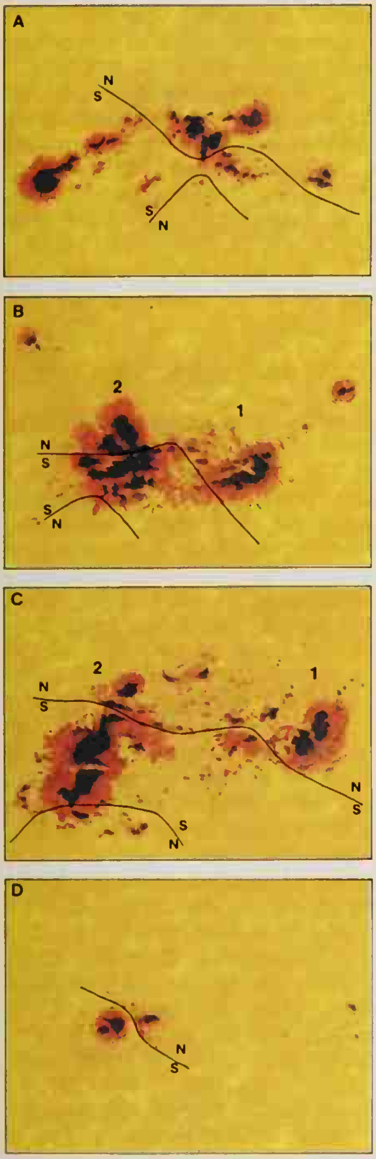
Sunlamps that produce rays with a wavelength below 2400 Å, known as abiotic rays, destroy life and can be used, for example, to sterilize the ulcers and bedsores of bedridden patients by killing the bacteria present. Other beneficial effects of artificial sunlight include the formation of vitamin D in those people who have rickets—a disorder involving a deficiency of vitamin D—and also increased blood circulation in the skin. Its use is discouraged in cases of tuberculosis because it may cause the disease to flare acutely.

Sunnites The term *Sunnites* refers to the great majority of the world's Muslims (see ISLAM), distinguishing them as the *ahl al-sunna wal-jamaa* ("the people of the sunna and the community") from the SHIITES. Sunnites are, by this definition, Muslims who strictly follow the sunna (practices) of the Prophet MUHAMMAD and preserve the unity and integrity of the community. Anyone who stands within the mainstream of the Islamic tradition and acts in accordance with generally accepted practices of the community is, therefore, a Sunni. Most Muslims see the sunna as complementary to the KORAN insofar as it explains certain points and elaborates some Koranic principles by offering details necessary for the practice of Islamic law.

sunspots A sunspot is a strongly magnetic and relatively dark area of the photosphere of the SUN. The darkest central area of a sunspot, the umbra, is roughly circular in shape and typically 18,000 km (11,000 mi) in diameter. The umbra is surrounded by a somewhat less dark annular region, the penumbra, roughly doubling the umbral diameter. The surface brightness of the umbral area is only about 20% of the corresponding total brightness of the undisturbed photosphere. The decreased emission corresponds to that of an (idealized) perfect blackbody radiator at the effective temperature of 3,700 K, compared to the photospheric effective temperature of 5,800 K. The corresponding relative brightness of the penumbra is about 75%, and its effective temperature is 5,400 K. Spots are distributed on the Sun mainly between ±40° solar latitude.

The development of a typical sunspot group begins when a loop of magnetic flux emerges from the solar interior through the photosphere. Several small spots become visible and move apart, growing in size over the next 5 to 10 days. The group decays over a period of weeks, but large spots may remain for months. Eventually, however, the random motions of the ionized gas near the photosphere act to disassemble the strands of the tube of magnetic flux.

The number of sunspots varies over an 11-year cycle in which spots first appear at higher solar latitudes, increase in number as they appear at lower latitudes, and finally diminish and cease as they appear within 7° of the solar equator. The latitude spread of the spots also narrows as the cycle proceeds. This cycle forms half of a 22-year magnetic cycle in which the polarities of the leading and trailing sunspots during the second 11-year period are opposite to polarities during the first 11-year period. The physical mechanisms underlying these cycles are not yet well understood, nor is it known why other, equally strong magnetic fields produce faculae, or photospheric brightenings, instead of sunspots. Related magnetic phenomena include the so-called ephemeral regions, spot-free and relatively small, that presage a sunspot cycle and



Upon detailed examination a sunspot is usually found to consist of two separate regions of smaller spots. Following the direction of solar rotation, these two regions are called the preceding and following spots. The dynamic nature of these two regions, which persist for no more than a few months, is seen in this 1947 sequence of a large bipolar group of sunspots. On February 11 (A) *the distinction between the two regions is unclear visibly, but close examination of their spectra reveals their opposite polarity. The distinction between the preceding spot* (1) *and the following spot* (2) *is clearer in March 9* (B) *and April 7* (C)*. Sunspot activity had virtually stopped in these regions by May 5* (D).

follow the same pattern but tend to have opposite polarities. One current explanatory model suggests that the 22-year cycles actually overlap and that spot formation is promoted by giant eddies in the solar convection zone that originate near the poles and break into cells as they move toward the solar equator.

sunstroke see HEATSTROKE

superconductivity Superconductivity is a low-temperature phenomenon in which a metal loses all electrical resistance. Electric currents can therefore flow through the metal without any dissipation of energy. In a ring of superconducting material, a current (the supercurrent) can thus flow indefinitely, provided the ring is always kept below the superconducting transition temperature (the threshold at which the metal becomes superconducting). Most metallic elements and hundreds of intermetallic compounds and alloys are superconducting. Most have transition temperatures between 1 and 10 kelvins (K) above ABSOLUTE ZERO, but since 1986 materials have been found that are superconducting at much higher temperatures.

The low temperatures needed to achieve superconductivity were first attained in 1907 by Heike Kamerlingh-Onnes at the University in Leiden (Holland) when he succeeded in liquefying helium gas. Liquid helium boils at 4.2 K at atmospheric pressure, and by reducing the vapor pressure, the temperature of the liquid helium can be further reduced to 1 K. Superconductivity was first demonstrated in 1911 with mercury at a temperature below 4.15 K, and as more metals were found to superconduct it was also observed that superconductivity could be suppressed by moderate magnetic fields. Each superconductor is thus characterized by its transition temperature and its critical magnetic field. No ferromagnetic or antiferromagnetic metals are superconducting.

The Meissner Effect. In 1933 the German physicist Walther Meissner and coworkers discovered that magnetic fields of a strength less than the critical field are expelled by superconductors, a phenomenon now known as the Meissner effect. This is strictly true only for ordinary, or Type I, superconductors, and they are said to be ideally diamagnetic. Because of this property, the Dutch physicists C. J. Gorter and H. B. G. Casimir were able to study the superconducting state thermodynamically.

Type II Superconductors. Type II superconductors are superconductors into which magnetic flux can penetrate at a critical field much less than the Meissner field and which remain superconducting up to a much larger critical field. Using Type II superconductors, it is possible to build magnetic solenoids that generate high fields in relatively large volumes of material with virtually no power dissipation. A special technology of high-field superconductors has developed since 1960 and is now of considerable economic importance. Almost any material can be made to exhibit Type II behavior by alloying it with other metals. The most important high-field superconductors are those which have high transition temperatures, because such materials also exhibit high critical magnetic fields. Examples are the niobium alloys Nb_2Zr (10.2 K), NbTi (9.5 K), and Nb_3Sn (18.1 K).

The BCS Theory. A microscopic theory of superconductivity was presented in 1958 by John BARDEEN, Leon N. Cooper, and John R. Schrieffer (the BCS theory), for which they were awarded the 1972 Nobel Prize in physics. It postulates that the conduction electrons, which in the normal state move more or less freely and independently through the lattice of the positive metal ions, condense into a state where pairs of electrons are correlated with each other. The pairing prediction was confirmed by experiments. Many other predictions of the BCS theory have also been confirmed by experiment, but the theory fails in describing some of the behavior of the high-temperature superconducting ceramics discovered in the late 1980s.

The Josephson Effect. In 1962, Brian D. Josephson in England correctly predicted that if two superconductors are separated by only a thin insulating oxide layer, it is possible for the electron pairs to pass through this barrier (see JOSEPHSON EFFECT). It is thus possible to sustain weak supercurrents in a ring of superconducting material containing such a junction. (Josephson was awarded the 1973 Nobel Prize in physics for this work.) These currents (now called Josephson currents), as well as two other quantum mechanical effects—the direct current (DC) and alternating current (AC) Josephson effects—have important practical applications, such as the measurement of very small electrical currents, in electronic microchips, and for precision measurements of Planck's constant.

Recent Developments. In recent years experimenters have developed a number of so-called heavy-electron superconductors, in which the effective masses of conducting electrons are larger than normal. These materials ($CeCu_2Si_2$ and UBe_{13} are examples), when superconducting, appear not to involve paired electrons moving in outer electron levels but, instead, electrons moving in lower, or denser levels. Scientists have also developed superconducting organic compounds.

The most startling development in recent years, however, was the discovery in 1986 of materials that were able to become superconducting at temperatures relatively much higher than any achieved before. The discovery was made by physicists J. George Bednorz and K. Alex Müller at the IBM Zurich Research Laboratory in Switzerland; they were subsequently awarded the 1987 Nobel Prize for physics for their work. The material they used, a mixture of lanthanum-barium copper oxides, proved superconductive at a temperature of 35 K. Since then, laboratories around the world have explored various combinations of copper oxides with yttrium, barium, and other metals in the search for still higher transition temperatures. Some of these materials have met full superconductivity criteria at temperatures well exceeding 120 K.

In 1988 a team of American physicists led by William A. Goddard III set forth a new theory of superconductivity based on the movement of electrons through the copper-oxide components of the new compounds. According to the theory, when a material becomes superconductive, a few electrons are displaced from the oxygen atoms, which causes the atoms to become magnetic. Adjacent copper atoms are pulled into line by the magnetism and lose electrons into the quantum pockets, or "holes," created by the displaced oxygen atoms. This process creates new "holes," and electrons will continue to flow through the material indefinitely as long as the transition temperature is maintained.

The theory, which has so far proven accurate, predicts a transition-temperature limit of about 200 K for the copper-oxide group of superconductors. A material could be cooled to that temperature by relatively inexpensive dry ice (solid carbon dioxide), and wide commercial applications would follow, particularly in the electronics industry (superconductors are already used in a wide variety of scientific and medical instruments). However, unless a group of materials that superconduct at room temperatures can be found, the use of superconductors in such large projects as magnetically levitated trains, power lines, and power storage facilities will be cost prohibitive.

See also: CRYOGENICS; SUPERFLUIDITY.

superego see PSYCHOANALYSIS

superfluidity Superfluidity is a peculiar state of matter exemplified by liquid helium at extremely low temperatures (see CRYOGENICS), characterized by frictionless flow and zero viscosity. Helium becomes a liquid at 4.2 K, which is the lowest boiling point of any substance. Liquid helium behaves like a normal fluid until it is cooled to 2.17 K, at which temperature its heat content Q drops dramatically. As the temperature is lowered further, an increasing fraction of the liquid condenses into a state of zero energy and zero viscosity in which it can flow unimpeded without any friction through the smallest orifices, provided only that the flow speed remains below a critical velocity (of order 300 cm/sec). If contained in a beaker, the walls of the beaker become covered with a superfluid liquid film that can rise to substantial heights (tens of centimeters) above the liquid level. An open beaker will slowly empty because the superfluid film flows over its edge.

The high apparent heat conductivity in the superfluid state—about 100 times better than that of copper—is a result of efficient hydrodynamic heat transport rather than actual heat conduction. If the liquid is heated in one region, superfluid is transformed into normal fluid there. The surrounding superfluid (which can carry no heat, because the atoms are in the lowest energy state) constantly flows toward the hot spot while normal fluid constantly carries heat away from it.

Liquid helium does not solidify even at absolute zero unless a substantial pressure (25 atmospheres) is applied to it. This fact is explained by the theory of quantum mechanics to be due to the zero-point motion of the atoms, which, because of their small mass, is especially large and prevents the formation of a crystal lattice. In order to solidify at zero pressure the helium atoms would have to give up kinetic energy in an amount not allowed by quantum theory. The superfluid state is similarly explained by quantum theory, which restricts the energy levels of the superfluid so that normal friction and viscosity cannot occur.

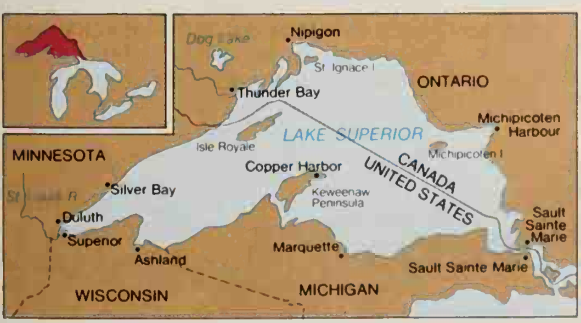
supergiant Supergiant stars are the brightest known stars. They are on the average about 10,000 times as bright absolutely as the Sun. In extreme cases they may be 100 times brighter still; such very bright stars are prominent in the Large Magellanic Cloud. Supergiants typically have masses ranging from 10 to 100 times the solar mass and radii varying from 20 to 1,000 times the solar radius. All spectral types occur among supergiants. They are young stars. Several of the brightest naked-eye stars are supergiants, including Rigel (β Orionis), Betelgeuse (α Orionis), Canopus (α Carinae), Antares (α Scorpii), and Deneb (α Cygni). Using large infrared telescopes, scientists have found evidence for a number of fast-moving supergiants circling the center of the Milky Way galaxy.

superheavy elements The term *superheavy* applies to any chemical element lying beyond the actinide series in the periodic table (elements with an atomic number higher than 103). Several elements immediately beyond the actinides have been produced by means of accelerators, but they are extremely short-lived radioactive forms not found in nature on Earth. Theorists have speculated that elements of far higher atomic number might exhibit nuclear stability because of the particular numbers of protons and neutrons in their nuclei, but no evidence has yet been found for their existence.

Superior, Lake Lake Superior, astride the U.S.-Canadian border, is the farthest north and west of the Great Lakes. Bordered on the west by Minnesota, on the south by Wisconsin and Michigan, and on the east and north by Ontario, it is the largest lake in the Western Hemisphere and one of the largest in the world. Measuring 563 km (350 mi) from east to west and more than 257 km (160 mi) north to south, the lake has a surface area of about 82,410 km^2 (31,820 mi^2). It achieves a maximum depth of 393 m (1,290 ft). As the headwater of the Great Lakes system, Lake Superior discharges into Lake Huron by way of the Saint Marys River. More than 200 rivers feed Lake Superior, including the Nipigon and the Saint Louis. The drainage basin measures about 209,500 km^2 (80,900 mi^2).

Major ports on the shores of the lake include Duluth, Minn.; Sault Sainte Marie, Mich.; Sault Sainte Marie, Ontario; Thunder Bay, Ontario; Superior, Wis.; and Two Harbors, Minn. Lake Superior is a vital shipping route for minerals from the region and grain from the prairies. The lake is a popular resort area in summer.

The first European to see the lake was Étienne Brûlé (1662). Its name comes from the French *Lac Supérieur*, meaning "upper lake." In 1959 the lake was linked to the Atlantic Ocean by the St. Lawrence Seaway.



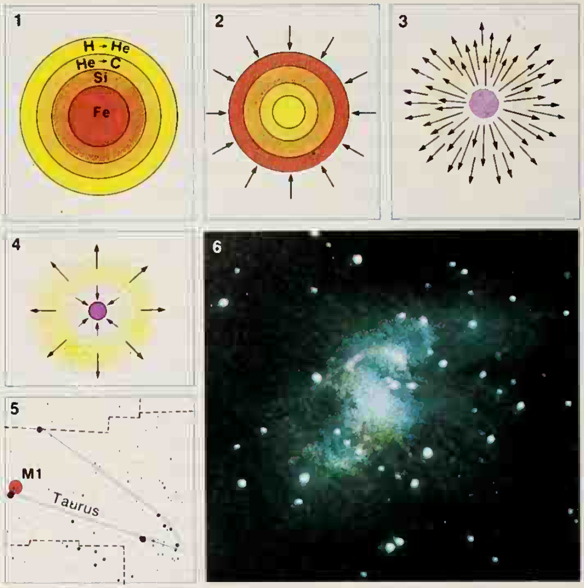
supermarket Supermarkets are large, self-service food stores, usually selling more than $2 million worth of products a year from at least 1,850 m^2 (20,000 ft^2) of floor area. In the late 1980s there were approximately 30,000 U.S. supermarkets—about 20% of all food stores—with total sales of $200 billion annually, roughly 75% of all food sales. The average supermarket will stock and sell many thousands of different items over a year. It carries a wide variety of both dry groceries and perishable foods—meats, produce, and dairy products. In recent years some supermarkets have broadened their offerings to include such disparate products as drugstore items, small appliances, books and magazines, toys, hardware, and even such services as insurance or brokerage sales. Many have in-store baking facilities, lunch counters, and delicatessens. The first self-service, departmentalized food market was opened in Memphis, Tenn., in 1916 by Clarence Saunders.

supernova A supernova is a star that explodes. It suddenly increases in brightness by a factor of many billions, and within a few weeks it slowly fades. In terms of the human lifespan, such explosions are rare occurrences. In our Milky Way galaxy, for example, a supernova may be observed every few hundred years. Three such explosions are recorded in history: in 1054, in 1572, and in 1604. The Crab nebula consists of material ejected by the supernova of 1054. Such materials, known as supernova remnants, are common in the heavens.

The supernovas observed in modern times have all occurred in other galaxies, the most distant yet having been detected in 1988 in a galaxy 5 billion light-years away. The most interesting supernova of recent times was detected in the relatively nearby Large Magellanic Cloud, on Feb. 23, 1987, by an astronomer at Chile's Las Campanas Observatory. It quickly became an object of intense study by all the means available to modern astronomy.

A supernova may radiate more energy in a few days than the Sun does in 100 million years, and the energy expended in ejecting material is much greater even than this. In many cases, including the Crab-nebula supernova, the stellar remnant left behind after the explosion is a neutron star—a star only a few kilometers in diameter having an enormously large density and consisting mainly of neutrons—or a pulsar, a pulsating neutron star.

There are two common types of supernovas, called type I and type II. Type I occurs among old stars of small



A supernova occurs when the outer, gaseous portion of a massive star explodes. According to one theory, as nuclear reactions in a star's core (1) *start to produce heavy elements, such as iron, continued contraction* (2) *of the inner core begins to release enormous amounts of energy. The star explodes* (3) *and expels stellar matter. The core continues to contract, probably producing a dense neutron star* (4). *A supernova in the constellation Taurus* (5) *was observed by Chinese astronomers in* AD *1054. Its remnants form M1, the Crab nebula* (6).

mass, whereas type II occurs among very young stars of large mass. It is not known how a small-mass star can release the very large amounts of energy needed to explain type I supernovas. Scientists generally believe that this must involve binary systems—two stars revolving around each other.

Stars with large masses burn their nuclear fuel very rapidly. Within a million years or less, such stars build cores containing much iron. When the iron eventually burns, energy is quickly drained from the core, and the star cannot continue to support itself against gravity. It suffers a mighty collapse analogous to that of a type I supernova, and the rebound causes matter to be ejected in a type II supernova explosion. Stars ending in this way are typically red SUPERGIANTS, but the one that exploded as 1987A was a blue star, named Sanduleak, with a mass only about 15 times that of the Sun. Its pattern of brightening and fading also varied notably from that of typical type II supernovas.

Cosmologists estimate that the universe came into existence about 15 billion years ago. This involved the initial creation of hydrogen and helium. Since then nuclear fusion in stars has changed some of the original hydrogen and helium into heavier elements (see STELLAR EVOLUTION). Supernovas have played an important role both in producing the heavy elements and in ejecting material back into space, where it has been used to make new stars and, probably, planetary systems. It is possible that one or more supernovas exploded shortly before the formation of our solar system. Elements ejected from these explosions could have mixed with the solar nebula, eventually becoming part of the structures of the Sun, the Earth, and all living things.

supersonic transport Flight at one to five times the speed of sound, or Mach 1 to Mach 5, is called supersonic flight (see AERODYNAMICS). Such speeds have been achieved by various military AIRCRAFT since the days of World War II, but the concept of a supersonic transport (SST)—a commercial craft that could fly faster than sound—did not draw serious attention until the 1950s. General Dynamics, builder of the first supersonic long-range bomber (the B-58 Hustler, in 1957), proposed a passenger version in 1955. From 1963 to 1971 the United States spent more than $1 billion on a series of Mach 3 SSTs, but in 1971 Congress cut off all funds for their development. During these years the Soviet Union had been developing and test-flying its own SST, the Tupolev Tu-144, which it introduced for passenger flights in 1975. After a series of problems with the plane, however, the Tu-144 was withdrawn from service in 1983. Currently, the only operating SST is the French-British CONCORDE, introduced for passenger service in 1976.

SSTs offer improved engine efficiency as a result of their speed, which causes airflow into the engine inlet to be compressed up to several times atmospheric pressure. The afterburning turbojets used by SSTs, however, are much noisier than the large-diameter turbofans of subsonic transports. Although the engines of an SST passing at cruising height cannot be heard, the shock waves produced by supersonic speeds are heard on the ground as a thunderlike boom. For this reason, SST routes other than in the Soviet Union have thus far had to be flown at subsonic speeds where the routes cross inhabited areas.

The Concorde, jointly developed by France's Aérospatiale and the British Aircraft Corporation, became (1976) the Western world's first operational civil supersonic transport.

superstition A superstition is a belief, sometimes only tentatively held, that cannot be justified in terms of a dominant belief system and may therefore be said to be irrational. The word often implies condemnation when used by persons who assume the superiority of their beliefs, whether scientific, religious, or philosophical. The explorers and missionaries of the last century, for example, often dismissed much of the worldview of the peoples they encountered as superstition.

The term *superstition* is often taken to mean beliefs concerning MAGIC, supernatural invisible forces, or erroneous nature lore. WITCHCRAFT, the EVIL EYE, omens, signs, ghosts, and a variety of spirit beings are all included in such a definition. Earlier folklorists and anthropologists sometimes saw in the superstitions of medieval Europe traces of earlier, more primitive culture. Psychologists have also taken an interest in the impulses behind superstition, both in its widest social forms and as expressed in individualized, personal beliefs.

superstring theories In theoretical physics, superstring theories are mathematical models that describe fundamental particles as extremely short (about 10^{-35} m), one-dimensional strings, rather than as zero-dimensional points. It is imagined that these strings are capable of twisting, looping, combining, and separating. They are also assumed to exist in more than four dimensions, with the additional dimensions rolled up in a tight space. Superstring theories are extremely speculative and remain unproven, but certain successful predictions of the models offer hope that they might eventually lead to a single theory of forces and particles (see GRAND UNIFICATION THEORIES). The earliest string theories were used, unsuccessfully, in late-1960s attempts to understand the strong nuclear force. They have since been combined with theories of supersymmetry, hence the name *superstring* (see SYMMETRY, physics).

supply and demand The economic theory of supply and demand states that in a competitive, or free, market, the interaction between the demand for and the supply of goods and services determines the prices charged for the goods and services.

Demand. Economists define demand as a schedule, or list, showing the various quantities of a particular product that can be sold at all possible prices in a given market during a given time period. The law of demand states that the relationship between price and the quantity demanded is an inverse one (see Figure 1). Experience shows that this rule is generally true; when merchants want to increase the sales of a product, they lower rather than increase its price. A decline in the price of a product has two effects on the consumer—an income effect and a substitution effect. The income effect indicates that a decline in the price of a product in effect increases a consumer's real income, enabling him or her to purchase a larger amount of the product under consideration. According to the substitution effect, a lower price will make the given product cheaper than other products, thereby prompting the consumer to substitute it for other products.

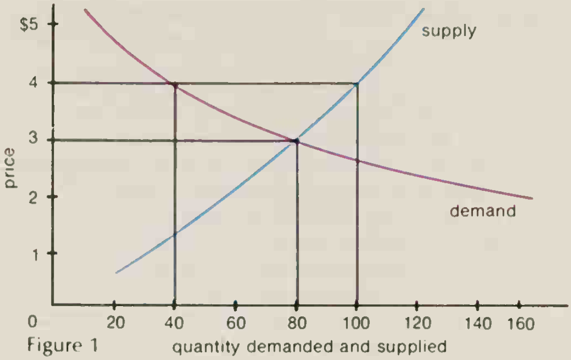


Figure 1

Supply. Supply is a schedule showing the various quantities of a good that producers or sellers will offer in the market at all possible prices during a given time period. The law of supply indicates that the relationship between the price of a product and the quantity supplied of that product is usually direct (as illustrated in Figure 1). The explanation for this relationship is that a firm usually encounters rising production costs as it expands output and, therefore, must obtain higher prices to cover these costs. Costs increase with output because certain productive resources—for example, the firm's plant and machinery—cannot be expanded in a short period of time. As the firm, therefore, increases the amounts of more readily augmentable resources such as labor, materials, and component parts, the fixed plant will become crowded or congested, resulting in a decline in efficiency of production and an increase in costs.

Price Equilibrium. The market, or equilibrium, price is determined where the quantity demanded and the quantity supplied are equal. For example, if the equilibrium price of a product is $3 and the equilibrium quantity is 80 units in a particular time period, any change in the equilibrium price will create an imbalance between the quantity demanded and the quantity supplied, resulting in a change in price to reestablish the balance. For instance, at any below-equilibrium price, such as $2, the quantity demanded will exceed the quantity supplied and a shortage will develop. Competing buyers will bid up the price, causing the quantity demanded to fall as buyers drop out of the market, and the quantity supplied will increase as suppliers respond to the higher prices by increasing output. Conversely, at an above-equilibrium price, such as $4, the quantity supplied will exceed the quantity demanded, and sellers will lower their prices in order to sell the surplus.

Shifts in Supply and Demand. Equilibrium price and quantity will change if the demand or supply curves shift. An increase in demand means that consumers now want to purchase more of this product at each possible price.

Potential causes for an increase in demand include a change in consumer tastes or preferences favorable to this product, an increase in consumer incomes, an increase in the price of a closely substitutable product, or an increase in the number of consumers in the market.

If supply remains constant, an increase in demand causes both equilibrium price and quantity to increase. An adverse change in consumer tastes, a decline in consumer incomes, a reduction in the price of a close substitute good, or a decline in the number of buyers in the market will all cause a decrease in demand, causing equilibrium price and quantity to decline.

Supply may also shift; that is, sellers may decide to offer either more or less of the product at each possible price. An increase in supply occurs when suppliers offer more of the product at each possible price. Possible causes that might change supply include a decline in production costs stemming from lower resource prices or improvements in productive techniques, or the entry of additional firms into the industry. An increase in supply will reduce equilibrium price but increase equilibrium quantity. A decrease in supply will cause equilibrium price to rise and equilibrium quantity to fall. Causes of a decrease in supply include rising production costs and the exodus of firms from the industry.

See also: MONOPOLY AND COMPETITION.

suprematism Suprematism was one of the most austere kinds of geometric ABSTRACT ART in the early part of the 20th century. Created in Russia by the painter Kasimir MALEVICH in 1913, the movement became influential in the west as a result of the German translation of his *Non-Objective World* published (1927) by the Bauhaus. It is one of the most important books on abstract art. Initially using only the square, Malevich then evolved a more complex art employing pure geometric shapes (see CONSTRUCTIVISM). His aim was to produce an art of what he called "pure feeling," devoid of the realism of objects in the visible world.

Supreme Court of the United States The Supreme Court of the United States, composed of a chief justice and eight associate justices, is at the apex of the U.S. judicial system. Provisions for the establishment of the Supreme Court were made in Article III of the U.S. Constitution. In addition to vesting judicial power in a Supreme Court and other lower courts to be established by congressional legislation, Section 1 of this article states that federal judges "shall hold their offices during good behavior"—their removal therefore can only be by IMPEACHMENT procedures—and judges' compensation cannot be reduced while they hold office. Section 2 of Article III sets forth the extent of federal judicial power and the Supreme Court's jurisdiction. The Supreme Court has original jurisdiction—that is, the authority to hear a case without that case being first heard elsewhere—over cases in which a state or a diplomat is involved (the 11th Amendment, however, restricts to some extent federal jurisdiction over suits against states). The Court's appellate jurisdiction can be regulated by Congress.

Members of the Supreme Court of the United States appear in this 1991 photograph: (left to right) *Justices Clarence Thomas, David H. Souter, Antonin Scalia, and Sandra Day O'Connor; Chief Justice William H. Rehnquist; and Justices John Paul Stevens, Harry A. Blackmun, Byron R. White, and Anthony M. Kennedy. Justice Thurgood Marshall, the Court's first black and a noted liberal, retired due to poor health in 1991. He was succeeded by Justice Thomas, a conservative Republican, after a bruising Senate confirmation battle.*

Justices are appointed by the president and confirmed by the Senate. The Constitution does not stipulate the size of the Court, leaving that determination to congressional statute. The familiar nine-member bench has been constant in size only since 1869; it began with six members in 1789 and had as many as ten justices in the period 1863–66. The Supreme Court of the United States is unique because it serves two functions, each of which must be carried on in a subtle relationship to the other. It is, first, a court of law, operating within the forms and rituals of Anglo-Saxon legal procedure with roots going back to 12th-century England; as such it is the highest court in the land, with a final authority over all adjudication whether originating in the federal or in the state courts. Because its pronouncements on U.S. law are final, they become guides for every judge and lawyer in the nation. In addition to being a court of law, the Supreme Court is a policymaking body. It is a political institution in the sense that it exerts a commanding influence on the public policies of the United States.

How Cases Reach the Court

The Supreme Court is primarily a COURT OF APPEALS. Cases generally reach the Court either from the lower federal courts or from the state supreme courts. There are three possible routes by which a case may come to the Supreme Court.

Certification. A lower federal court may send up a question of law for instructions, a process called certification.

Appeal. Some cases are appealed to the Court as a matter of right under the Judiciary Act of 1925. Such cases fall into eight categories. A litigant may appeal from the highest state court in which a decision may be had if that court (1) has invalidated a federal statute or treaty; or (2) has upheld its own law or constitutional provision allegedly in conflict with federal laws, treaties, or the U.S. Constitution. A litigant may appeal from a federal court of appeals if (1) a federal law or treaty has been declared unconstitutional; or (2) a state law or constitutional provision has been held to conflict with a federal law, treaty, or the Constitution. Finally, it is possible to appeal directly from a federal district court to the Supreme Court if (1) a federal statute with a criminal penalty is invalidated; (2) a judgment has been rendered under the antitrust laws, the Interstate Commerce Act, or Title II of the Federal Communications Act; (3) a three-judge court has either issued or denied an injunction to restrain enforcement of a state or federal law; or (4) a one-judge court has held a federal law unconstitutional. The right of appeal is subject to certain technical restrictions, and the Court has some discretion in deciding to accept such cases.

Certiorari. Most of the cases reviewed by the Supreme Court reach the bench on a writ of certiorari, a Latin term meaning to be informed of or to be made certain in regard to. In English practice certiorari was a writ that commanded judges of inferior courts to return records or certify proceedings for review by a higher court, and this is essentially its practical meaning today.

Under the Court's rules, a petition for a writ of certiorari is granted only "where there are special and important reasons therefor." Among these reasons are the following possibilities: when two federal courts of appeals or two 3-judge federal district courts have rendered conflicting decisions; when a state court or a federal appellate court has passed on an important question of federal law on which the Supreme Court has never made a pronouncement; or when a federal court has so far departed from the accepted canons of judicial proceedings as to call for exercise of the Supreme Court's powers. Generally the Court accepts only 10 to 15 percent of the annual certiorari petitions.

The Process of Review. When a litigant who loses in a lower court wishes to take the case to the Supreme Court, he or she may send a request for a hearing, whether by appeal or by certiorari, to the office of the chief justice, who circulates it among the eight associate justices. All nine justices take part in the decision whether to hear the case. The number of requests runs from 4,000 to 4,500 annually, of which only about 150 are decided by full opinion. Every justice must personally review the records; if four justices are in favor of taking a case, it is placed on the docket. If a case is rejected, the decision of the last court in which it was heard stands; such a rejection does not, the Court maintains, necessarily indicate approval of the lower court's ruling.

Once a case is accepted for review, it is placed on one of three dockets, the original, the appellate, or the miscellaneous—the latter including a large number of petitions, often handwritten, filed by indigent persons, many of whom are serving time in prison. Any person who executes an oath that he or she is without any financial resources may, under a federal statute, sue in forma pauperis (as a poor person) in any federal court without paying filing fees, transcript costs, or other expenses usually connected with a lawsuit.

How the Court Operates

The Supreme Court opens its sessions in October of each year and usually adjourns toward the end of June. On rare occasions it may call a special session, but it has done so only four times in this century. A normal session now lasts about 38 weeks, but justices often work between sessions as well. During the term the Court devotes four days in two weeks of each month to oral argument in cases chosen for full treatment; it then spends two weeks in recess for researching and writing opinions.

Attorneys submit written briefs to the Court. Oral argument gives the justices a chance to ask questions and add to their knowledge of a case. It also gives the public an opportunity to see the Court in action (188 seats are available on a first-come, first-served basis), although the Court's most important work is done behind closed doors. In the Court's early years, lawyers might have argued a case for days, but attorneys are now usually limited to half an hour. No opinion is written or decision rendered until after the Court has met in conference and discussed the cases. The conference is unusual for a public body because it is closed to all but the nine justices. No official record is kept, and whatever is said remains forever secret unless the justices wish to divulge something, which they rarely do.

Presiding over the conference is one of the most important tasks of the chief justice, who may in this role exert a special influence over colleague justices. The chief justice presents the cases for discussion, controls the debate, and assigns the writing of opinions. The chief justice presents his view of the case first, then elicits the opinions of the other justices in order of seniority. After all have expressed their views, a vote is taken in reverse order. If the chief justice is in the majority, he will later formally assign the writing of the opinion; if he is in dissent, the most senior justice in the majority makes the assignment. Although the assigning of opinions is simply a parceling out of the work, some political strategy is involved, because the opinion of a particular justice may carry more weight on a given question than that of others. Some develop special expertise; some are more highly respected generally. Chief justices tend to write some of the most controversial opinions, but generally all of the justices are given the opportunity to speak for the Court in significant and not simply routine cases. Chief Justice Earl WARREN, for example, wrote for the Court in cases involving public school desegregation and the extension of rights to persons accused of a crime, but he assigned to others the opinions in key civil-liberties cases.

All justices may record their own views of a case. If a justice is among the majority, but disagrees with the reasoning supporting the decision, that justice may write a concurring opinion in which the view is expressed that although the case was correctly decided, it should have been supported on different constitutional grounds. Any or all of those who believe that the case was wrongly decided may write dissenting opinions in which they mar-

JUSTICES OF THE SUPREME COURT

Justice	*Dates**	*Appointed By*
John Jay†	1789–95	George Washington
John Rutledge	1789–91	George Washington
William Cushing	1789–1810	George Washington
James Wilson	1789–98	George Washington
John Blair	1789–96	George Washington
James Iredell	1790–99	George Washington
Thomas Johnson	1791–93	George Washington
William Paterson	1793–1806	George Washington
John Rutledge †	1795 ‡	George Washington
Samuel Chase	1796–1811	George Washington
Oliver Ellsworth †	1796–99	George Washington
Bushrod Washington	1798–1829	John Adams
Alfred Moore	1799–1804	John Adams
John Marshall †	1801–35	John Adams
William Johnson	1804–34	Thomas Jefferson
H. B. Livingston	1806–23	Thomas Jefferson
Thomas Todd	1807–26	Thomas Jefferson
Joseph Story	1811–45	James Madison
Gabriel Duval	1811–35	James Madison
Smith Thompson	1823–43	James Monroe
Robert Trimble	1826–28	John Quincy Adams
John McLean	1829–61	Andrew Jackson
Henry Baldwin	1830–44	Andrew Jackson
James M. Wayne	1835–67	Andrew Jackson
Roger B. Taney †	1836–64	Andrew Jackson
Philip P. Barbour	1836–41	Andrew Jackson
John Catron	1837–65	Andrew Jackson
John McKinley	1837–52	Martin Van Buren
Peter V. Daniel	1841–60	Martin Van Buren
Samuel Nelson	1845–72	John Tyler
Levi Woodbury	1845–51	James K. Polk
Robert C. Grier	1846–70	James K. Polk
Benjamin R. Curtis	1851–57	Millard Fillmore
John A. Campbell	1853–61	Franklin Pierce
Nathan Clifford	1858–81	James Buchanan
Noah H. Swayne	1862–81	Abraham Lincoln
Samuel F. Miller	1862–90	Abraham Lincoln
David Davis	1862–77	Abraham Lincoln
Stephen J. Field	1863–97	Abraham Lincoln
Salmon P. Chase †	1864–73	Abraham Lincoln
William Strong	1870–80	Ulysses S. Grant
Joseph P. Bradley	1870–92	Ulysses S. Grant
Ward Hunt	1872–82	Ulysses S. Grant
Morrison R. Waite †	1874–88	Ulysses S. Grant
John Marshall Harlan	1877–1911	Rutherford B. Hayes
William B. Woods	1880–87	Rutherford B. Hayes
Stanley Matthews	1881–89	James A. Garfield
Horace Gray	1881–1902	Chester A. Arthur
Samuel Blatchford	1882–93	Chester A. Arthur
Lucius Q. C. Lamar	1888–93	Grover Cleveland
Melville W. Fuller †	1888–1910	Grover Cleveland
David J. Brewer	1889–1910	Benjamin Harrison
Henry B. Brown	1890–1906	Benjamin Harrison
George Shiras	1892–1903	Benjamin Harrison
Howell E. Jackson	1893–95	Benjamin Harrison
Edward D. White	1894–1910	Grover Cleveland
Rufus W. Peckham	1895–1909	Grover Cleveland
Joseph McKenna	1898–1925	William McKinley
Oliver W. Holmes, Jr.	1902–32	Theodore Roosevelt
William R. Day	1903–22	Theodore Roosevelt
William H. Moody	1906–10	Theodore Roosevelt
Horace H. Lurton	1910–14	William H. Taft
Charles Evans Hughes	1910–16	William H. Taft
Edward D. White †	1910–21	William H. Taft
W. Van Devanter	1910–37	William H. Taft
Joseph R. Lamar	1911–16	William H. Taft
Mahlon Pitney	1912–22	William H. Taft
James C. McReynolds	1914–41	Woodrow Wilson
Louis O. Brandeis	1916–39	Woodrow Wilson
John H. Clarke	1916–22	Woodrow Wilson
William Howard Taft †	1921–30	Warren G. Harding
George Sutherland	1922–38	Warren G. Harding
Pierce Butler	1922–39	Warren G. Harding
Edward T. Sanford	1923–30	Warren G. Harding
Harlan F. Stone	1925–41	Calvin Coolidge
Charles Evans Hughes †	1930–41	Herbert Hoover
Owen J. Roberts	1930–45	Herbert Hoover
Benjamin N. Cardozo	1932–38	Herbert Hoover
Hugo L. Black	1937–71	Franklin D. Roosevelt
Stanley Reed	1938–57	Franklin D. Roosevelt
Felix Frankfurter	1939–62	Franklin D. Roosevelt
William O. Douglas	1939–75	Franklin D. Roosevelt
Frank Murphy	1940–49	Franklin D. Roosevelt
James F. Byrnes	1941–42	Franklin D. Roosevelt
Harlan F. Stone†	1941–46	Franklin D. Roosevelt
Robert H. Jackson	1941–54	Franklin D. Roosevelt
Wiley Rutledge	1943–49	Franklin D. Roosevelt
Harold H. Burton	1945–58	Harry S. Truman
Frederick M. Vinson†	1946–53	Harry S. Truman
Tom C. Clark	1949–67	Harry S. Truman
Sherman Minton	1949–56	Harry S. Truman
Earl Warren†	1953–69	Dwight D. Eisenhower
John Marshall Harlan	1955–71	Dwight D. Eisenhower
William J. Brennan, Jr.	1956–90	Dwight D. Eisenhower
Charles E. Whittaker	1957–62	Dwight D. Eisenhower
Potter Stewart	1958–81	Dwight D. Eisenhower
Byron R. White	1962–	John Kennedy
Arthur J. Goldberg	1962–65	John Kennedy
Abe Fortas ‡	1965–69	Lyndon Johnson
Thurgood Marshall	1967–91	Lyndon Johnson
Warren E. Burger†	1969–86	Richard Nixon
Harry A. Blackmun	1970–	Richard Nixon
Lewis F. Powell, Jr.	1972–87	Richard Nixon
William Rehnquist	1972–86	Richard Nixon
John P. Stevens	1976–	Gerald Ford
Sandra D. O'Connor	1981–	Ronald Reagan
William Rehnquist†	1986–	Ronald Reagan
Antonin Scalia	1986–	Ronald Reagan
Anthony M. Kennedy	1987–	Ronald Reagan
David H. Souter	1990–	George Bush
Clarence Thomas	1991–	George Bush

* Dates begin with year of nomination. †Chief justices. ‡Never confirmed by the Senate as chief justice.

shal the arguments for their position. Often opinions are unanimous, and rarely are so many opinions written in a case that the constitutional question involved remains unsettled. Recent examples of such a situation are *New York Times Company* v. *United States* (1971) and University of California v. Bakke (1978). Nine separate opinions were written in the first case and five in the second. In the *Times* case, the court held that the newspaper could not be restrained from publishing certain classified documents; in Bakke, it ruled that a white applicant had been denied admission to the university because of his race. In each instance, however, the law was left fragmented and uncertain, inviting additional litigation.

The justice who has written the majority opinion, which becomes the official opinion of the Court, delivers it from the bench. Over the years the style has varied with the individual justice. Some simply read the opinion in full; others summarize the major points. Justice Felix Frankfurter used to amaze reporters and onlookers by expounding his opinions from memory, including the citing of volume and page numbers of pertinent cases bearing on the one at hand. The process of handing down opinions may take from an hour to several days, depending on the number of decisions and the styles of the justices involved. It is a sober and dignified procedure throughout, from the moment the red velvet draperies are opened and the black-robed justices take their seats to the time the chief justice declares the session ended.

The Court as a Political Force

From the day on which Chief Justice John Marshall rendered the historic decision in Marbury v. Madison (1803), which established the principle of judicial review—that is, the right of the Court to declare acts of Congress unconstitutional—the Supreme Court has had a significant impact on U.S. public policy. John Marshall not only implanted the cornerstone but constructed the entire foundation of U.S. constitutional law. In Gibbons v. Ogden (1824) he interpreted the commerce power—the power the Constitution gives Congress to regulate interstate commerce—in the broadest possible terms, and in McCulloch v. Maryland (1819) he firmly wrote the Federalist doctrines of national supremacy and implied powers into the Constitution of the United States. Marshall's successor as chief justice, Roger B. Taney, helped precipitate the Civil War with his opinion in Dred Scott v. Sandford (1857) that free blacks and slaves were not citizens of the United States within the meaning of the Constitution. The post–Civil War period contained two parallel developments: the curbing of state regulatory powers through the use of the due process clause of the 14th Amendment (1868) and the restriction of national power through a narrow interpretation of the powers of Congress, particularly that of regulating interstate commerce. Important among these decisions were *Munn* v. *Illinois* (1877) and *Lochner* v. *New York* (1905). A major constitutional crisis arose in the 1930s over the question of federal and state regulation of the economy. President Franklin D. Roosevelt, angered by the Supreme Court's invalidation of much of his recovery legislation, notably in *Schechter Poultry Corporation* v. *United States* (1935) and *Carter* v. *Carter Coal Company* (1936), proposed to Congress that the size of the Court be increased from 9 to 15 justices—which was, in effect, asking for permission to pack the Court with supportive members. The plan failed, but within a year the Supreme Court was upholding economic regulatory legislation. Important cases were *National Labor Relations Board* v. *Jones & Laughlin Steel Corporation* (1937) and *United States* v. *Darby* (1941).

The Supreme Court emerged once again as a major force in American life under the chief justiceship of Earl Warren from 1953 to 1969. Known for its consistent protection of civil liberties, the Warren Court will be remembered particularly for three revolutionary decisions: Brown v. Board of Education of Topeka, Kansas (1954), which outlawed segregation in the public schools and spearheaded the civil rights movement of the 1950s and '60s; *Baker* v. *Carr* (1962), which ordered equitable reapportionment of the state legislatures and guaranteed a close approximation of the "one man–one vote" principle; and Miranda v. Arizona (1966), which curbed coercive police techniques by insisting that prior to any interrogation a suspect must be told of his or her rights.

Although the Court under Chief Justice Warren E. Burger (1969–86) retreated from some Warren positions, it did not overrule any of the major Warren decisions. It stirred major controversy with its 1973 decisions, in Roe v. Wade and Doe v. Bolton, striking down state laws prohibiting abortions.

In 1981, Sandra Day O'Connor became the first woman justice of the Supreme Court. In 1983 the Court declared unconstitutional a congressional veto over executive acts (*Immigration and Naturalization Service* v. *Chadha*).

A conservative majority in 1984 redirected the law in several areas. The justices upheld the principle of seniority over minority preference in jobs (*Firefighters* v. *Stotts*) and a city's right to include a Nativity scene in a public Christmas display (*Lynch* v. *Donnelly*). Controversially, the exclusionary rule was relaxed in two decisions that granted permission to use: (1) a defective search warrant under certain conditions (*United States* v. *Leon*) and (2) illegally obtained evidence with proof that it "inevitably" would have been discovered lawfully (*Nix* v. *Williams*). In a major ruling in 1991 the Court held (*Arizona* v. *Fulminante*) that the admission in error of a coerced confession as evidence in a trial need not necessarily require that a conviction be overturned if enough other evidence of guilt exists.

The retirements of Lewis F. Powell, Jr., 1987, William J. Brennan, Jr. (1990), and Thurgood Marshall (1991) shifted the balance of the Court toward the conservative. They were replaced, respectively, by Anthony M. Kennedy, David H. Souter, and Clarence Thomas.

Supremes, The see Ross, Diana

Surabaya [soo-rah-bah'-yah] Surabaya, the capital of East Java Province, Indonesia, is situated on the Mas River. Its population is 2,345,000 (1985 est.). Sugar, coffee, tobacco, and spices are exported from its outport of Tandjungperak, north of Surabaya. Fishing, shipbuilding, textile manufacturing, and petroleum refining are important. Airlangga University (1954) is there. Surabaya was the main base of the Dutch East Indies before 1942. While under occupation by the Japanese during World War II the city was bombed by the Allies.

surface tension Surface tension is a phenomenon associated with the interface between a fluid and another phase. One example involves the water-air interface. Because of surface tension, a steel needle can float on water if it is gently lowered to rest on the surface.

Within a liquid, each molecule has similar molecules attracting it uniformly in every direction. At the surface, there exists a net attraction toward the interior, causing the surface molecules to crowd together. In the absence of other forces, surface tension causes the liquid to tend toward the shape of a sphere, the volume having the least surface area.

When a drop rests on a flat surface, the surface tension between liquid and surface causes wetting fluids (such as water) to spread out and nonwetting fluids (such as mercury) to contract. Wetting fluids in a container rise where in contact with the container wall until their weight is balanced by the surface attraction (see CAPILLARITY); nonwetting fluids correspondingly drop until balance is reached.

surface-to-air missile Surface-to-air missiles (SAMs) are mobile, tactical rockets used to defend civil and military targets from attack by aircraft or missiles. The most well-known SAMs are those deployed by the USSR in the Middle East since the 1960s. Of these, the largest, the SAM-5 deployed in Syria in 1983, is 16.5 m (54 ft) long and has a range of 250 km (150 mi). With its associated large radar array, it can detect and attack planes flying at very high altitudes. Smallest in size are portable SAMs for use by individual soldiers on the battlefield (about 1.5 m/5 ft long). The U.S. Patriot SAM played an important role in the defense of cities in Israel and Saudi Arabia during the GULF WAR. Most surface-to-air missiles use solid propellants because they require a rapid reaction, but a few of the older long-range missiles rely upon liquid propellants. Separate booster rockets are sometimes used, and are jettisoned when burned out. Some SAMs employ ramjet sustainer motors.

Guidance techniques range from simple optical aiming with a heat-seeking homing head in the missile to very sophisticated systems. The two most common systems are beam-riding systems, in which the target is tracked by radar, TV, or laser and the SAM automatically follows this beam to the target; and command guidance systems, in which separate trackers are provided for the target and the SAM, with guidance commands transmitted to the SAM by a command link.

See also ANTIAIRCRAFT SYSTEMS; ROCKETS AND MISSILES.

surfbird The surfbird, *Aphriza virgata*, is a SHOREBIRD in the sandpiper family, Scolopacidae, subfamily Arenariinae, which also includes turnstones. Surfbirds are about 254 mm (10 in) long, with short, yellow legs and a short, straight yellow bill. In summer they are heavily streaked and spotted, but in winter their upper parts are dark. For most of the year they feed along the rocky Pacific coast, ranging from Alaska south to the Straits of Magellan. In summer they retreat to their breeding areas high in the mountains of Alaska, where the female surfbird lays four eggs among the rocks at the base of cliffs.

surfing Surfing is a water sport that involves controlled planing on the sloping portion of a wave as it moves toward shore. The most basic form of the sport is bodysurfing, which is performed without the use of any type of board: a person in the water first swims toward shore to match the wave speed, then stiffens the body in order to provide a rigid surface that will plane on the front of the shore-rushing wave.

In the mid-1950s surfboards of lightweight balsa wood, fiberglass, and polyurethane were introduced, replacing the heavy wooden boards of earlier years. These boards had the advantages of low weight and high maneuverability. To surf using these boards, the participant paddles the board, while lying on it, until the board reaches wave speed. Then the rider attempts to stand up and plane on the board toward shore. Surfboards weigh 11–18 kg (24.2–39.7 lb) and are 1.8–3.7 m (6–12 ft) in length. The boards are slightly rockered so that the middle is lower than the nose or the tail of the board. The boards have a skeg, or fin, that acts as a lateral stabilizer. Another form of surfing, with a different type of board, is belly-board surfing. The participant planes on the slope of the wave in a prone position with a board about 91 cm (3 ft) long supporting only the chest area. Surfing demands the grace of a gymnast coupled with good balance, sense of timing, and coordination, all important because boards can reach speeds of 55 km/h (34 mph).

The sport of surfing is very popular along the coasts of Hawaii, California, New Zealand, Australia, South Africa, Puerto Rico, Peru, Great Britain, and Brazil. It originated

A surfer rides a tall wave, balanced in a crouching position. Many variations of this sport exist, the most popular being long-board surfing, which permits the rider to stand erect as the board is carried shoreward.

in Hawaii and was used by the nobility, who surfed on long wooden boards, as a form of religious ceremony. In 1920, Duke Kahanamoku of Hawaii, the Olympic swimming champion, formed the first surfing club in Waikiki and was largely responsible for popularizing the sport. Surfing is also a competitive sport.

A relative of surfing is windsurfing, invented by Californian Hoyle Schweitzer, who patented the first board design in 1969. Competition is held in three classes—Windsurfer, Mistral, and Windglider—each with two or more weight divisions for men and a separate class for women. Boardsailing, as the sport is also called, became part of the Olympic agenda in 1984, but—erroneously, experts maintain—as a yachting event (Windglider class). Five-time world champion Stephan van den Berg of the Netherlands won the gold medal. The winner in 1988 was New Zealander Bruce Kendall.

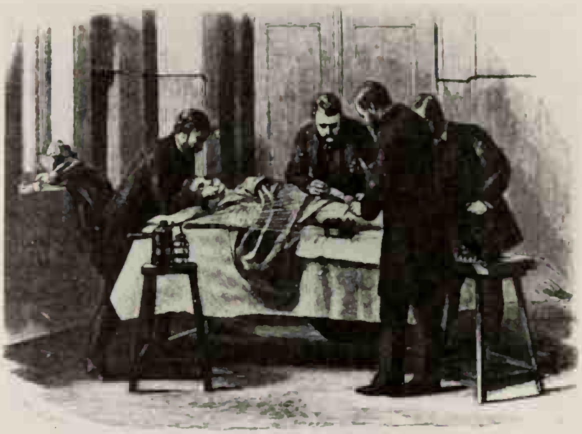
surgeonfish Surgeonfishes, or tangs, family Acanthuridae, comprise about 100 species of reef fishes with deep, compressed bodies. The scalpels are strong, sharp-edged spines found on each side of the body, just ahead of the tail. The spine folds into a groove; when the fish is frightened, the spine snaps forward and is capable of producing a severe cut in humans. Most surgeonfishes are less than 50 cm (20 in) in length.

surgery Surgery is the use of operative procedures to treat injuries, diseases, and disorders. These procedures include the mending of wounds and broken bones; the repair or removal of diseased or injured tissues, organs, and limbs and their replacement if possible; and the remodeling of body structures. Surgical practice also includes diagnosis, preoperative and postoperative care, and supervision of patients during rehabilitation (see REHABILITATION MEDICINE).

Surgery and nonsurgical medicine have vied with each other throughout history in dealing with medical problems. Medicine was dominant until the 20th century, and surgery's chief concern was mainly obvious injuries, such as those stemming from accidents or war. At one time the vast majority of HOSPITAL patients were medical, whereas in the 20th century surgical cases tend to occupy the majority of hospital beds.

Historical Background

Surgery has been practiced since long before recorded history (see MEDICINE, HISTORY OF). For example, skulls of the Neolithic Period indicate the practice of trephining, or the cutting or drilling of a hole in the skull of a live person. Whether this was done as a magic rite, as a way to relieve pain, or as a treatment of skull fracture is not known. The earliest recorded medical writing, found in Egyptian papyri, describes the surgical treatment of injuries to the head, shoulders, chest, and spine. At least 2,000 years ago, surgeons in India were able to remove urinary stones as well.



Surgeons in 19th-century England use Dr. Joseph Lister's carbolic-acid spray to prevent infection during an abdominal operation. Lister's antiseptic techniques reduced sharply the rate of patient deaths.

Even the earliest known practitioners of surgery made use of a wide range of tools. These included knives (scalpels and lancets), awls, drilling devices, scissors, saws, forceps, clamps, syringes, mirrors (specula), tubes for viewing or extracting fluids or foreign materials from body canals (catheters), needles, sutures, casts, splints, and bandages. Prosthetic devices such as simple ARTIFICIAL LIMBS made of wood and metal were also employed in ancient times, as were glass eyes and other simple cosmetic replacements of body parts. In addition, early practitioners of surgery were well aware of the desirability of pain relief for patients, but few recourses were possible except the use of alcohol or other stupefying agents.

Surgery nevertheless remained only a skilled trade until knowledge of human anatomy could be based on observation rather than simply on the writings of GALEN and other ancient authorities. In Europe, anatomical studies based on human dissection did not begin until the late 13th century. By the 16th century the Flemish physician Andreas VESALIUS had swept away the errors of Galen and disposed of an accumulated baggage of medieval superstitions and legends. The most enthusiastic supporter of Vesalius's work was Ambroise Paré, often considered the father of modern surgery.

Surgeons who were equally knowledgeable as anatomists and practitioners could be found throughout Europe by the 18th century, and in the following century anatomical knowledge encompassed virtually all structures visible to the naked eye. Nonetheless, except in rare circumstances, no surgeon dared to enter a body space such as a joint or the abdomen. What a surgeon could do was limited by the pain of operating on a conscious person, the danger of postoperative infection, and the difficulty of making a diagnosis before surgery. The modern use of ANESTHETICS to deal with pain began in 1846. (Anesthetic agents had been used earlier in the 19th century with success, but the medical profession was unaware of these events.) Besides relieving pain, anesthetic agents enabled surgeons to work slowly and carefully and thus to carry out procedures never before possible.

The problem of postoperative infection was addressed in 1847 by the Hungarian physician Ignaz Semmelweis. Working in Vienna, he showed that puerperal sepsis, a uniformly fatal infection that sometimes followed childbirth, was probably transmitted to women in labor by the unwashed hands of physicians or attendants. His work was met with violent opposition, however, by the medical establishment of the day. When French chemist Louis PASTEUR later proved that infections were the result of bacterial invasion, this suggested to British surgeon Joseph LISTER that wound putrefaction could be avoided by the use of an ANTISEPTIC during surgery. The first operation using Listerian antiseptic procedures was performed on Aug. 12, 1865. Over the next three decades the operating room became a nearly germ-free environment.

The third need for modern surgery was improved diagnostic methods. One major landmark was the introduction, in 1819, of the use of the STETHOSCOPE for listening to chest sounds. Another was the development of techniques for analyzing blood and urine. A third was the development by the German physician Rudoph Virchow of cellular pathology. Perhaps the discovery with the most immediate effect on surgery was that of X RAYS, in 1895.

Modern Surgery

In the 20th century a vast number of diagnostic and supportive techniques were developed, particularly in recent decades. Progress in the imaging of internal structures for diagnosis (see RADIOLOGY) included the invention of computerized axial tomography (the CAT scan), NUCLEAR MAGNETIC RESONANCE imaging, and a number of other methods. Computer technology made possible automatic chemical and cellular analyses of blood and other samples. Through the development of long, flexible tubes called ENDOSCOPES, surgeons were in some cases enabled both to visualize and to operate on deep-lying regions of the body with minimal trauma to the patient. Surgeons also learned how to thread catheters through blood vessels into the heart, and they developed techniques such as balloon ANGIOPLASTY to deal with the problem of arteries obstructed by atherosclerosis.

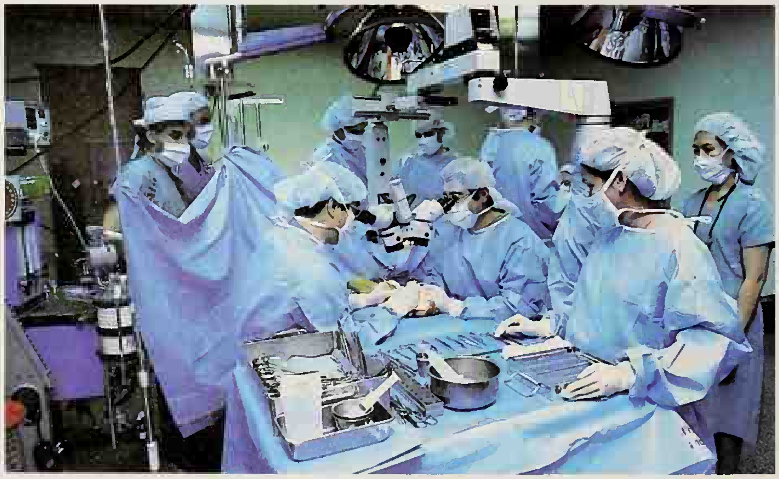
Advances in the ability to maintain vital body functions before, during, and after surgery were at least as dramatic. Support machinery developed for these purposes included the HEART-LUNG MACHINE, inhalation therapy devices, anesthesia machines, cardiac-monitoring devices, and cardiac defibrillators. The development of BLOOD BANKS as resources for transfusions was also of major importance.

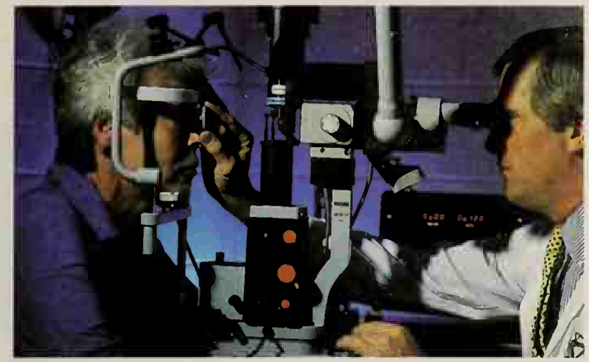
Surgical capabilities were also greatly widened by the introduction of microsurgery, that is, the use of magnifying systems and very precise tools to operate at the microscopic level. Using such methods, surgeons could reattach vessels and nerves of severed limbs, operate on the inner ear, remove tumors of the spinal cord, and perform other such operations once considered impossible. Through drug advances and other developments, surgeons also became increasingly able to transplant organs (see TRANSPLANTATION, ORGAN) and to replace organs and other body structures with ARTIFICIAL ORGANS.

Among other technologies, intense beams of LASER light can be used as cutting and cauterizing tools in many circumstances. The focused pulses of sound waves from ULTRASONIC devices can be used in diagnostic imaging and to break up kidney stones and gallstones.

With such expanding technical possibilities, the era when a surgeon might be expected to practice any type of operation has passed. Ten major divisions of modern surgery are generally recognized. GYNECOLOGY deals with the female genital organs and lower urinary tract; OBSTETRICS

(Below) *Microsurgeons are able to reattach the nerves and muscles of a severed limb or digit by using microscope viewers to observe the field of operation.* (Right) *Open-heart surgery is made possible by a heart-lung machine to oxygenate and recirculate the blood.*





(Above) *An ophthalmologist adjusts a laser's focus prior to operating on a patient's eye. Surgical uses of lasers are growing, because lasers often eliminate the need for an incision and because they reduce blood loss by sealing blood vessels.*

A surgeon performing a kidney transplant walks the healthy organ from its donor to the recipient in the operating room. Kidney transplants have been the most successful of such operations, but many other organ transplantations are being performed with a growing rate of success as new drug treatments are found to deal with rejection by the patient's body.

is concerned with pregnancy and childbirth problems (and is now combined with gynecology as a single surgical division). OPHTHALMOLOGY is the study and treatment of eye diseases. ORTHOPEDICS deals with problems related to bones, joints, and related structures. Otolaryngology treats the ear, nose, throat, and larynx. Urology deals with diseases of the urinary tract.

General surgery treats the digestive tract, abdominal organs, breasts, and endocrine glands. Thoracic surgery deals with the chest wall and vessels and organs found in the chest. PLASTIC SURGERY involves repair of injuries or deformities. Colon and rectal surgery, and neurological surgery are the remaining specialties (see MEDICINE).

Each surgical division has its own accrediting board for the training of surgeons, and several of the boards have subspecialty fields with additional requirements. A surgeon-to-be first obtains a medical license, following a program previously accepted by the Residency Review Committee for the specialty involved. At the end of training, the appropriate specialty board conducts an examination for certification. The surgeon must then become entitled to use the facilities of a given hospital.

Surgical Procedures

Surgery may be categorized according to the scope of the operation and the degree of urgency. Thus the category of *emergency surgery* is reserved for injuries or medical crises of a life-threatening nature requiring immediate surgical intervention, as in embolisms (blood clots), massive wounds, and widespread major burns. Situations requiring prompt but not immediate attention, as in many cases of cancer, are classified as *urgent surgery*. Medical conditions that must be dealt with surgically but that can await attention for a period of weeks or months, as in cases of cataract, fall into the category of *required surgery*. *Elective surgery* involves conditions that preferably should be dealt with surgically but where an operation is not considered essential, as in removal of a minor cyst or burn scars. Finally, operations such as those dealing with unessential, cosmetic changes are called *optional surgery*.

Minor surgical operations, such as the removal of a small skin growth, may be performed in a surgeon's office or hospital facilities on an outpatient basis. Major surgery, however, involves the use of hospital operating rooms and large teams of medical personnel. For operations conducted on other than an emergency basis, a detailed program of preoperative and postoperative procedures must also be observed. A coronary bypass operation may be used as an example of major surgery, because cardiac surgery is in many respects a model for the direction of modern surgery. The surgeon works with an assistant surgeon as a member of a large team that includes cardiologists, catheterization teams, heart-lung pump teams, radiologists, anesthesiologists, echocardiography teams, and nurses. A host of other hospital workers are also involved.

A bypass operation involves removing a section of a large leg vein and grafting it between the aorta and a portion of the coronary artery that lies beyond the point of obstruction or other problem that necessitated the operation. Once this maneuver is completed, all incisions are closed and the patient is wheeled to a special room for recovery from anesthesia. The patient is then removed to an intensive-care unit and monitored to detect any postoperative problems. He or she is eventually returned to a hospital bed and is released from the hospital when recovery is sufficiently complete.

See also: DENTISTRY.

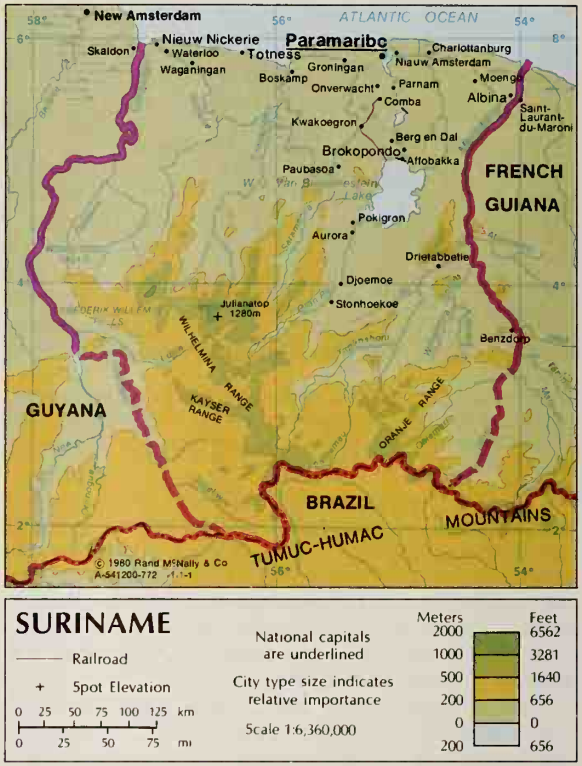
suricate [sur'-uh-kayt] The suricate, or meerkat, *Suricata suricata*, is an animal of the civet family, Viverridae, closely related to the MONGOOSE. Found in southern Africa, it either burrows (in plains areas) or lives in rock crevices. It is 25 to 37 cm (10 to 15 in) long, with a tail nearly as long, and it weighs less than 0.5 kg (1 lb). The coat is light gray with black horizontal stripes on the back and a whitish head. Suricates eat insects, snakes, and small mammals.

Surinam toad The Surinam toad, *Pipa pipa*, is actually a relatively large, tongueless, and highly aquatic frog in the family Pipidae. The frog is widely distributed in Amazonian South America and Trinidad. It has a greatly flattened body with a length of 12 to 20 cm (5 to 8 in), a pointed nose, and small, lidless black eyes. The hind legs are strong and extensively webbed and are used for swimming. The slender forelimbs have long, tactile fingers with starlike tips, which are used to sift through mud in search of prey. The Surinam toad is usually light brown with dark brown patches on its back. It eats such animals as insects, worms, crustaceans, and small fish. The reproductive habits of these frogs are unique. The eggs are deposited on the female's back, become embedded, and develop in individual pockets of skin. Eggs develop directly into small adult frogs in about 16 weeks.

Suriname [sur'-ee-nam] The Republic of Suriname is located on the northern coast of South America. It is bordered on the east by French Guiana, on the north by the Atlantic Ocean, on the west by Guyana, and on the south by Brazil. Suriname, formerly Dutch Guiana, became independent in 1975.

Land, People, and Resources

South of a fertile coastal lowland, about 80 km (50 mi) wide, lies a densely forested upland area, which rises to 1,280 m (4,200 ft) at Juliantop, the nation's high point.



AT A GLANCE

REPUBLIC OF SURINAME

Land: Area: 163,270 km^2 (63,039 mi^2). Capital and largest city: Paramaribo (1988 est. pop., 67,905).

People: Population (1990 est.): 396,813. Density: 2.4 persons per km^2 (6.3 per mi^2). Distribution (1988): 65% urban, 35% rural. Official language: Dutch. Major religions: Hinduism, Islam, Roman Catholicism, Protestantism.

Government: Type: military-civilian rule. Legislature: National Assembly. Political subdivisions: 9 districts.

Economy: GNP (1989): $1.3 billion; $3,020 per capita. Labor distribution (1985): agriculture and forestry—16.8%; mining—4.7%; manufacturing—11.1%; trade—12.9%; government—40.5%; services—5.9%. Foreign trade (1988 est.): imports—$365 million; exports—$425 million. Currency: 1 Suriname guilder = 100 cents.

Education and Health: Literacy (1985): 90%. Universities (1990): 1. Hospital beds (1985): 1,964. Physicians (1985): 219. Life expectancy (1990): women—71; men—66. Infant mortality (1990): 40 per 1,000 live births.

The presidential palace in Paramaribo, the capital and principal city of Suriname, reflects the influence of Suriname's Dutch colonial heritage.

The chief rivers are the Courantijn, Suriname, and Nickerie. Suriname has a rainy, tropical climate, with a mean annual temperature of 27° C (81° F). Precipitation at Paramaribo is 2,210 mm (87 in) and is even higher in the interior.

The population is highly diverse. About 31% are of mixed ancestry, mostly descendants of African slaves and persons of other races. About 15% are Indonesians, and 37% are Asiatic Indians. Most Surinamese live along the coast near PARAMARIBO, the capital. About 200,000 live in the Netherlands.

Dutch is the official language. English and Sranang Tongo, or Taki-Taki, a local patois, are widely spoken. School attendance to age 12 has been compulsory since 1876, and literacy is high. The University of Suriname opened in 1968.

Suriname, long one of the most properous countries in Latin America, was one of the world's leading exporters of bauxite. By the late 1980s, however, attacks by antigovernment guerrillas had a crippling effect on the economy, particularly the mining and processing of bauxite, which had represented about 80% of exports. Rice, oil palms, sugar, coffee, and fruit and garden crops are grown on the limited arable land, which comprises 0.4% of the territory. Fishing is of increasing importance. Industries include food processing and the manufacture of consumer goods.

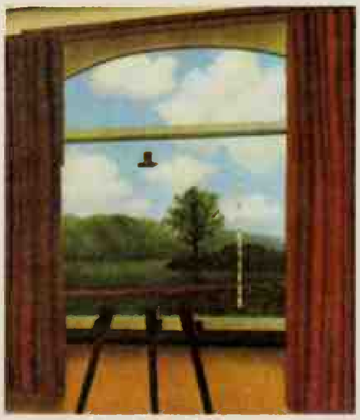
History and Government

Suriname was colonized by both the British and the Dutch in the 17th century, but under the Treaty of Breda (1667) the Dutch acquired the territory from the British in exchange for Manhattan Island. During the Napoleonic Wars, sovereignty passed to the British, but in 1815 the Dutch regained control. A plantation economy developed during the 18th and 19th centuries, based on imported black-slave labor. After slavery was abolished in 1863, laborers were brought from the East Indies and India. Beginning in the 1920s, bauxite production revolutionized the colony's economy. The country gained full independence on Nov. 25, 1975.

In 1980, Prime Minister Henck Arron was overthrown, and a national military council led by Lt. Col. Dési Bouterse assumed power. The execution of 15 civic leaders in 1982 led to the suspension of Dutch aid and the rise of an antigovernment guerrilla movement. Bouterse installed and removed a succession of civilian governments and appointed (1985) a national assembly that drafted a new constitution retaining a strong role for the military. Elections in November 1987 gave the opposition a majority in the National Assembly, and in January 1988 the assembly elected Ramsewak Shankar, a civilian, to a 5-year term as president. Shankar was overthrown in a bloodless coup in December 1990. In March 1991, Bouterse and the chief rebel leader reached a tentative peace accord. Parties favoring a commonwealth-type relationship with the Netherlands won a two-thirds legislative majority in the May 1991 elections, but it was unclear whether the army could be convinced to end its involvement in politics.

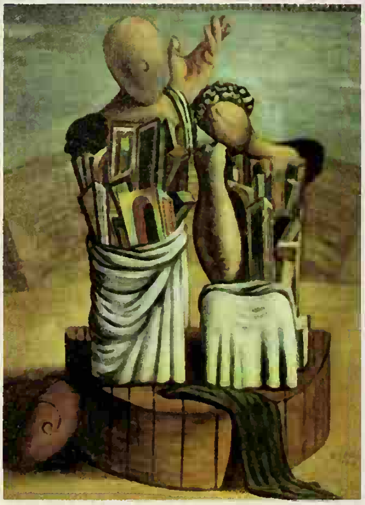
surrealism (art) Surrealism in art—a style in which imagery is based on fantasy and the world of dreams—grew out of a French literary movement founded during the 1920s. The term *surrealist* was coined by Guillaume Apollinaire in 1917; the artistic movement, however, came into being only after the French poet André BRETON published the first surrealist manifesto, *Manifeste du surréalisme*, in 1924. In this book Breton suggested that rational thought was repressive to the powers of creativity and imagination and thus inimical to artistic expression. An admirer of Sigmund Freud and his concept of the subconscious, Breton felt that contact with this hidden part of the mind could produce poetic truth.

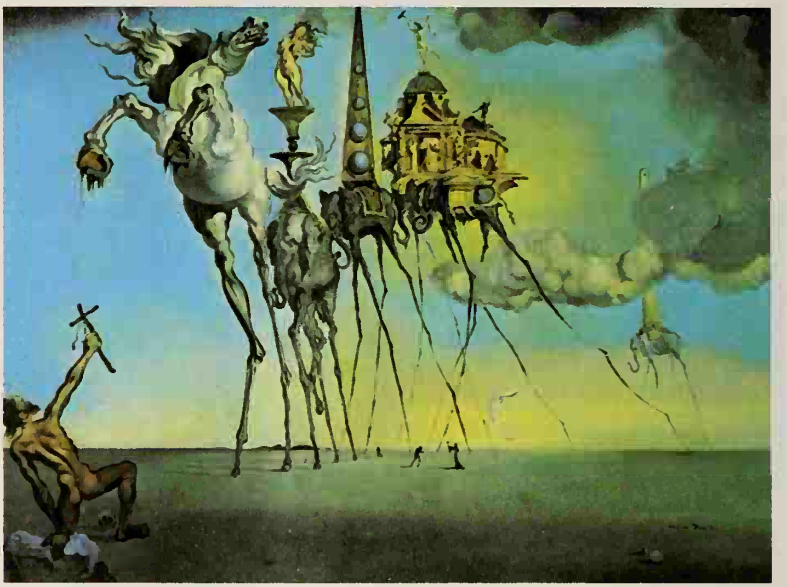
Breton soon recognized the kinship between his literary aims and the artistic aims of certain painters fascinated by Freudian concepts. In 1925, with Breton's encouragement, the first group exhibition of surrealist



The Human Condition I *(1934) exemplifies René Magritte's restrained depiction of the surreal. The paradoxes and incongruities in Magritte's work reveal a more intellectual approach to the representation of another reality than other surrealist painters. (Claude Spaak Collection, Choisel, France.)*

(Below) *The ambiguities and classical motifs of Giorgio de Chirico's work are seen in* Death of a Spirit *(1926). During the early 1920s, Chirico began to abandon his abstruse "metaphysical" style—which greatly influenced the surrealists—for a more academic style. (Private collection.)*





(Above) *Salvador Dalí's* Temptation of Saint Anthony *(1946) resurrects a theme found in the works of medieval and Renaissance artists. The bizarre elongations and huge scale of the creatures evoke the menace of the irrational. (Private collection.)*

painting took place in Paris. Among those included were Giorgio de Chirico, Max Ernst, André Masson, Joan Miró, Pablo Picasso, and Man Ray.

The presurrealist paintings of de Chirico, done before 1919, were of particular influence to certain of the surrealists, including Max Ernst, Salvador Dalí, René Magritte, and Yves Tanguy. These painters developed a dreamlike, or hallucinatory, imagery that was all the more startling for its highly realistic rendering. Other painters, including Miró and Masson, used biomorphic forms and accidental effects that approached abstraction. Their work influenced the beginnings of abstract expressionism in the United States during the 1940s.

Although it began partly as a reaction to Dada, surrealism benefited from Dada's liberating effects. Some of Dada's techniques were adopted by the surrealists, including assemblage, a form of sculpture consisting of combinations of incongruous objects and materials. Meret Oppenheim's *Object (Fur-Lined Cup and Saucer)* (1936; Museum of Modern Art, New York City) is a key example. Ernst's surreal "novels," two books of collages of strangely unrelated images, were a continuation of his Dada collage concepts.

The surrealist painters also looked to the past for inspiration, to such painters of fantasy as Hieronymus Bosch, to the Mannerists, and to the romantic and symbolist movements, as well as to primitive art and the art of the insane. Whether or not surrealism has ceased as a movement, its influences can be detected in all the major art movements that have come into being since 1945.

surrealism (film, literature, theater) Surrealism, meaning above realism, is an antiaesthetic movement that grew out of the nihilistic Dada movement of the years during and immediately after World War I. Its range being that of human thought itself, surrealism is limited in scope and application only by the human capacity for self-expression, which surrealists aim to expand. Writing, painting, film, sculpture, or any other art form assumes significance for the surrealist when it expresses a surrealist state of mind.

Surrealism began as a revolt against the control exercised by rationality over accepted modes of communication. The first surrealists attacked inherited preconceptions about the nature and function of word poems. In 1919, André Breton and Philippe Soupault produced the first specifically surrealist text, *Les Champs magnétiques* (Magnetic Fields, 1921), by so-called automatic writing, in which the surrealist banishes deliberate intent, leaving the pen free to express on paper the uncensored images that well up from the subconscious.

Seeking to embrace all forms of creative expression in their liberative effort to attain what Breton in his 1924 *Manifeste du surréalisme* (Manifesto of Surrealism) called "the true functioning of thought," the surrealists set about attacking, on the broadest possible front, conventions, prescribed rules, and consecrated values—cultural as well as aesthetic. This explains, for instance, their enthusiasm for the films of Luis Buñuel, whose *L'Age d'or* (The Golden Age, 1930) surpassed in violent iconoclasm even his first movie, *Un Chien Andalou* (An Andalusian Dog, 1928).

In its negative attitude toward literary and artistic tradition and in its opposition to the heritage of Western culture, surrealism superficially resembled Dada, the movement with which some of its earliest members, including Louis ARAGON, Roger Vitrac, Breton, Soupault, and its greatest poet, Benjamin Péret, all had been affiliated. However, surrealism marked a stage beyond the nihilism that had inevitably brought Dada to self-destruction. Surrealism was truly international, and exponents of its revolutionary principles shared an unshakable faith in the power of the imagination to revitalize poetry and art, and to compensate for the sociopolitical and religious forces that they found so oppressive and stultifying in contemporary society.

Surrey [sur'-ee] Surrey is a county in southeastern England, immediately southwest of London along the River Thames. It has an area of 1,679 km^2 (648 mi^2) and a population of 999,800 (1988 est.). Kingston upon Thames (1987 est. pop., 133,900) is the county's administrative center. Surrey is mainly low-lying and is drained by the Wey and Mole rivers. The borough of Epsom and Ewell is known for Epsom Downs, where the Derby, a classic horse race, is run. Dairying, market gardening, and the cultivation of wheat and oats are important. Radio and radar equipment and aircraft are manufactured.

Surrey has been settled since the Paleolithic Period. It was Romanized after AD 43. Since the Middle Ages, its history has been strongly influenced by the proximity of London.

Surrey, Henry Howard, Earl of The English poet Henry Howard, Earl of Surrey, b. Hunsdon, Hertfordshire, 1517, d. Jan. 19, 1547, is best remembered for his elegant sonnets published in *Tottel's Miscellany* (1557). His translation of books 2 and 4 of Vergil's *Aeneid* is the first example of blank, or unrhymed, iambic-pentameter verse in English. After a distinguished career as a soldier and courtier, Surrey was executed on a trumped-up charge of treason.

surrogate motherhood Surrogate motherhood is the practice of bearing a child or children on behalf of another woman. Either the child is conceived through ARTIFICIAL INSEMINATION, or an already fertilized egg is implanted in the womb. In the United States the practice has become an increasingly popular but highly controversial alternative for married couples who want to have children but cannot do so because of infertility or other health problems that preclude pregnancy (see FERTILITY, HUMAN). Since the first such arrangement in 1976, hundreds of children have been born to surrogate mothers in the United States. The process begins with a formal agreement—usually handled by a lawyer or specialized agency—between a married couple and a prospective surrogate mother. The surrogate agrees to the technique to be used and, if pregnancy is achieved, agrees to surrender the baby to the couple upon birth. The couple pay all medical, legal, and insurance fees, as well as a set fee to the surrogate.

Legal and ethical controversies surround the practice of surrogate motherhood. Various groups condemn the practice and seek to have it banned. Its supporters acknowledge the need for legislated guidelines and regulations, recognizing the enormous complications that can result; in South Africa, for example, a woman carried and gave birth to the triplets of her own daughter and son-in-law. The first U.S. test case of the legality of a surrogacy contract was the highly publicized "Baby M" case, in which the surrogate mother refused to surrender the newborn child. The New Jersey Superior Court upheld the contract, but in 1988 the state's Supreme Court reversed the ruling. It banned commercial surrogacy contracts and gave the surrogate mother broad visitation rights. A few other states have laws against commercial contracts, including Florida, Kentucky, Louisiana, Michigan, and Nebraska. Further state rulings are being sought.

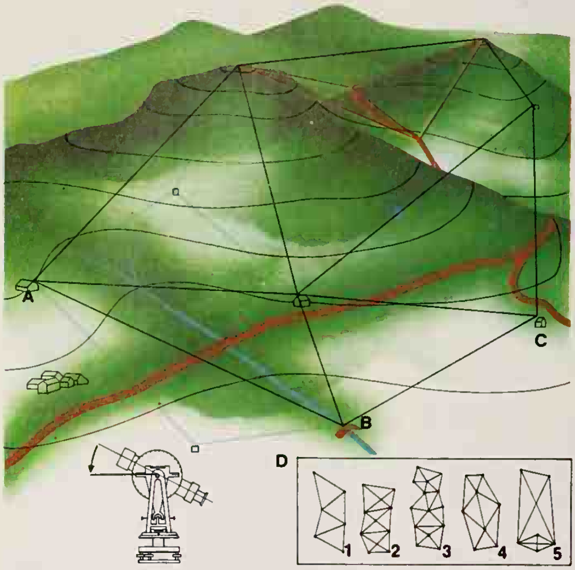
In countries other than the United States, surrogacy is far less common, and Great Britain has outlawed surrogate birth by commercial contract. A number of countries are considering bans. Elsewhere, motherhood by proxy consists mainly of private arrangements with no legal standing.

surveying Surveying is the practice of determining large dimensions with a high degree of accuracy, either to measure existing relationships (preliminary surveying) or to provide the means to build according to designers' plans (construction stakeout). Preliminary surveying is necessary to obtain information for all mapping; construction stakeout is necessary to control the location of all but the smallest or least significant construction project.

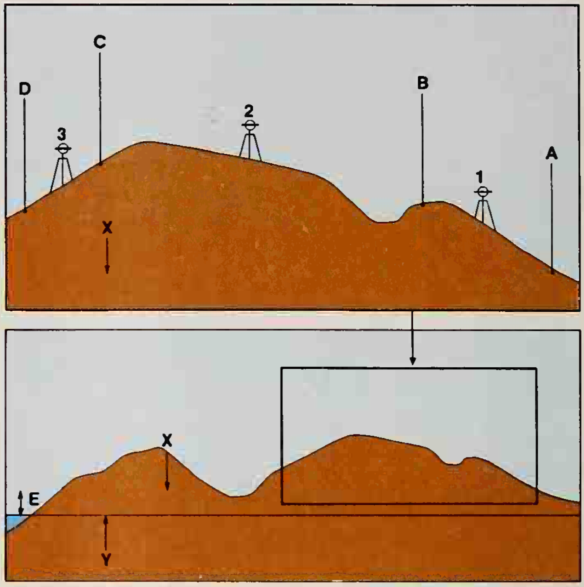
The Egyptians used surveying methods as early as 1400 BC to reestablish boundary markers obliterated by the Nile's flood waters. As long ago as 2900 BC their pyramids were built with an accuracy that indicates construction was controlled by surveying. The Babylonians, about 3500 BC, produced maps to an accurate scale, which indicates that field information was obtained by surveying and plotted to scale using surveying principles in miniature.

Surveying theory is based on the principles of geometry and trigonometry, and the methods used are based on the principles of physics. Each survey must be accomplished with the proper accuracy; too much accuracy is needlessly expensive, and too little does not accomplish the intended purpose.

Surveying measurements are made vertically, on a plumb line directed toward the Earth's center, and horizontally measured perpendicular to plumb line. All objects bear relationships to each other that can be expressed by the horizontal direction, horizontal distance, and vertical distance between them; surveying is a technique to measure and lay out these three dimensions. The three relationships among objects can seldom be estab-



Triangulation uses triangle networks to survey an area. A baseline (AB) *is measured between points of known elevation and position; a transit* (below, left) *set at these points measures angles to point* (C). *Angle* (C) *and lengths* (AC and BC) *are derived, and more triangles can then be measured. First order points* (blue and red grids) *are those measured with highest precision. Triangle chains include* (D): *triangles* (1); *braced quadrilaterals* (2); *centered quadrilaterals* (3); *double-centered triangles* (4); *and narrow quadrilaterals* (5).



In measuring the height of a hilly area, a measuring rod is first staked at a known elevation called the bench mark (X). *A leveling instrument is positioned* (1) *to sight the rod at position* A *and then at position* B, *and the difference in height is measured. The instrument is then moved to a second bench-mark position* (2), *and point* C *is measured; at position* 3 *the instrument uses point* C *to measure point* D. *The heights of all these points can be related to sea level* (Y) *by knowing the height of the bench mark* X *above sea level* (E).

lished directly. The usual procedure is to set a framework of convenient points and accurately determine their relationships—horizontal distances and directions, elevations only, or all three. This constitutes a control. Objects located relative to any point of the control can all be located relative to each other, either mathematically or graphically.

Methods. A traverse, the most common horizontal control, consists of a series of points called stations, each of which is located in the field by angle and distance from adjacent stations. Each station is selected for convenience and marked with a nail in the top of a wood stake. The traverse returns to the starting point to form a polygon. Triangulation is used for the most accurate horizontal controls over large areas but may also be used as a control whenever it is more convenient than a traverse.

Vertical control is established with a level circuit starting and ending at a point of known elevation, a bench mark (BM), with other bench marks set along the circuit. The difference between the known elevation of the starting point and its elevation determined at the end of the circuit is the error of closure.

In stakeouts, existing objects are located in the field by angle, distance, and elevation measurements from the points of a control survey.

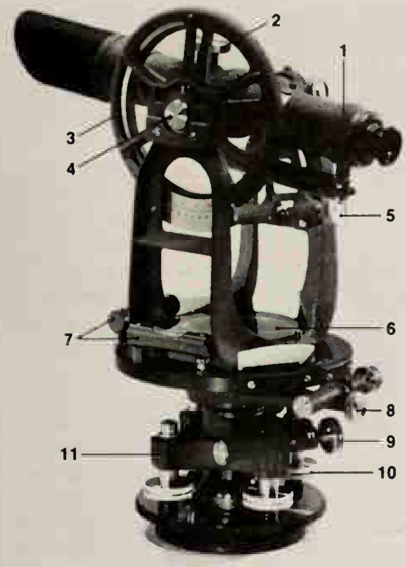
Most surveying involves plane surveying methods, which ignore the curvature of the Earth. In very large surveys, however, curvature of the Earth must be considered, and a special method, called geodetic surveying, is required. Latitudes and longitudes are taken into account and triangulation is most often used as a means of measurement.

Equipment. Horizontal angles are measured with transit or theodolite instruments that are equipped with a telescope and leveling screws and vials. For ordinary work horizontal distances are measured with accuracy and efficiency by using measuring tapes of fabric for rough work and of steel for greater accuracy.

Electronic-distance-measuring (EDM) equipment, which transmits an impulse of electromagnetic energy from one point to another from which it is reflected to the original point, gives very high accuracy at both short and long distances. The instrument converts travel time and velocity into the distance between points.

Optical triangles are also used to measure distances. Stadia measurements are made by reading the length of vertical rod that is subtended by the angle between two lines of sight. The lines of sight are fixed by stadia hairs in a transit or theodolite so that the rod length between them is always one-hundredth of the distance from the center of the instrument to the rod. Many distances can be quickly determined, but not with great accuracy, by using the same sighting for angle and distance.

Types of Surveying. Surveying is divided into many types according to its purpose. Topographic surveying specifically involves determination of the shape of the



An American transit is a surveying instrument used to measure horizontal angles and lines. This device includes a telescope (1), *with a focusing knob* (2); *a vertical circle* (3), *with an elevation axis* (4) *and an elevation tangent screw* (5); *a compass* (6), *with plate levels* (7); *an eyepiece for optical plummet* (8); *a lower-motion tangent screw* (9); *a leveling screw* (10); *and a leveling head* (11).

ground surface, but the term is generally used to describe surveying to obtain information for maps.

Information for maps of areas up to several hectares in size is obtained by plane or geodetic surveying, and information for larger maps is obtained by aerial photography. Certain small, conspicuous objects in the aerial photographs are accurately located as part of a control survey from which all other objects are positioned on the map.

Surveys for mapping the bottom of bodies of water are called hydrographic surveys. Route surveys are made to prepare maps for the design of such facilities as highways and pipelines. Land, or cadastral, surveying includes locating and marking property boundaries and determining property areas. It requires a knowledge of legal principles as well as of surveying methods. Each state licenses land surveyors to practice within that state.

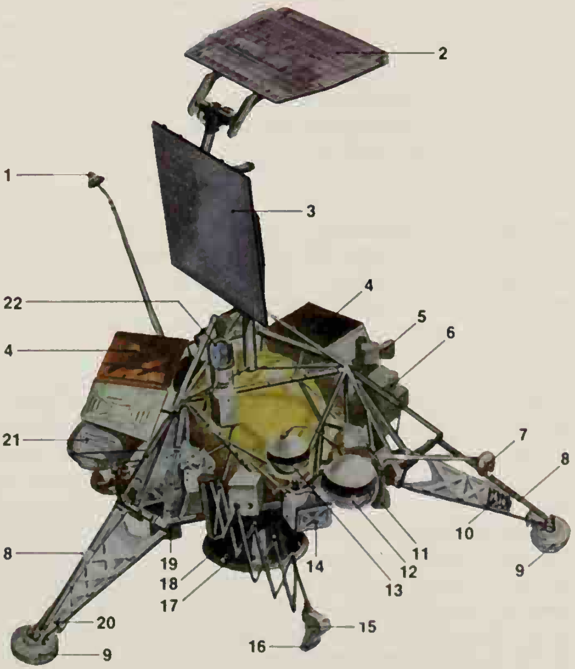
Construction surveying involves setting marks to control construction. Construction includes buildings, bridges, highways, and pipelines as well as highly accurate determinations of the required directions for electromagnetic-wave propagation and spacecraft launching.

Also included in construction surveying are the control of underground tunneling and mining, the control of underwater dredging, and the positioning of navigational aids in water.

Surveyor The first U.S. landings on the Moon were achieved by the automatic Surveyor spacecraft. Seven missions, five of them successful, were launched be-

(Left) *A theodolite is a surveying instrument that measures angles with greater accuracy than does a transit. It is smaller than a transit, with its controls enclosed in a cover, and has a telescope equipped with prisms rather than lenses.*

The Surveyor 3 *spacecraft made a soft landing on the Moon on Apr. 20, 1967. Two years after it stopped functioning, the spacecraft was visited (November 1969) by the* Apollo 12 *astronauts, who retrieved its television camera. Tests showed that the spacecraft carried live bacteria that had somehow survived the harsh environment of space. Numbers indicate: omnidirectional antenna* (1); *square solar panel* (2), *providing 89 watts of power; high-grain antenna* (3); *thermally controlled compartment* (4); *Canopus sensor* (5), *for guidance; flight-control sensor group* (6); *omnidirectional antenna* (7); *landing leg* (8); *footpad* (9); *accelerometer amplifier* (10); *vernier rocket engine* (11); *vernier propellant pressurizing tank* (12); *gas tank* (13) *for controlling attitude; auxiliary battery* (14); *soil sampler* (15), *with maximum extension of 1.5 m (5 ft); digging scoop* (16); *antenna* (17); *retro-rocket nozzle* (18); *crushable block* (19), *for absorbing touchdown impact; jet nozzle* (20) *for control of pitch and yaw; radar altitude and Doppler velocity sensor* (21); *and television camera* (22).



tween May 30, 1966, and Jan. 7, 1968; the spidery spacecraft touched down under their own guidance in a test of soft-landing technology for the coming Apollo missions. In addition to merely touching down safely, the Surveyors were also instrumented to study aspects of the lunar surface environment—dust, temperatures, solar effects, and so on—that might affect human astronauts. In addition, the robot landers carried out a variety of pioneering analyses of the lunar surface material.

Surveyor 1, launched May 30, 1966, landed in the southwest portion of the Moon's Oceanus Procellarum on June 2. In 7 months of operation it sent back 11,240 television pictures. The second Surveyor, launched Sept. 20, 1966, was lost when it crashed into the Moon three days later. *Surveyor 3*, launched Apr. 17, 1967, landed on April 20 in eastern Oceanus Procellarum, equipped again with a television camera but with a significant addition: a telescoping arm capable of digging trenches, moving rocks, and conducting other tests with the surface material. Although it functioned only 2 weeks, the craft provided 6,326 pictures, and the sampling arm was able to excavate the Moon to a depth of 17.5 cm (7 in).

Surveyor 4, launched July 14, 1967, crash-landed, presumably on July 16, although its transmissions abruptly ceased about 2 ½ minutes before it was to reach the ground. The first direct chemical measurements were made by *Surveyor 5*, launched Sept. 8, 1967, and landing September 11. *Surveyor 6*, launched Nov. 7, 1967, not only landed safely on November 10 in Sinus Medii, essentially in the center of the Moon's visible hemisphere, but scored a first by taking off again—on a single, 2-m-long (6.5-ft) sideways hop. It took 29,952 pictures.

The four previous Surveyor successes effectively freed the remaining probe, *Surveyor 7*, to be sent to a site of primarily scientific, rather than safe-landing, interest. The chosen site was in a rough region north of the relatively young crater Tycho, selected because it is in the lunar highlands, removed from the mare terrain typified by the other Surveyor sites. Launched Jan. 7, 1968, *Surveyor 7* landed on January 10.

Susann, Jacqueline Novelist Jacqueline Susann, b. Philadelphia, Aug. 20, 1921, d. Sept. 21, 1974, catapulted to fame and fortune on the strength of several sensational novels dealing with the seamy side of life among the rich and influential. One of them, *Valley of the Dolls* (1966; film, 1967), proved to be the world's all-time best-seller, and others, such as *The Love Machine* (1969; film, 1971) and *Once Is Not Enough* (1973; film, 1975), were also successful both as books and as films.

Suso, Heinrich [zoo'-zoh] A German monk and mystic, Heinrich Suso, or Seuse, b. Mar. 21, 1295?, d. Jan. 25, 1366, studied under the famous mystic Meister ECKHART at Cologne. He wrote *The Little Book of Truth* (*c.*1329), a defense of Eckhart, for which he was rebuked by his superiors and deprived of his teaching position at Constance. He then became an itinerant preacher, traveling widely in Switzerland before returning to monastic life. His principal work is *The Little Book of Eternal Wisdom* (*c.*1348), an influential book of meditations. He was beatified in 1831. Feast day: Mar. 15 (formerly Mar. 2).

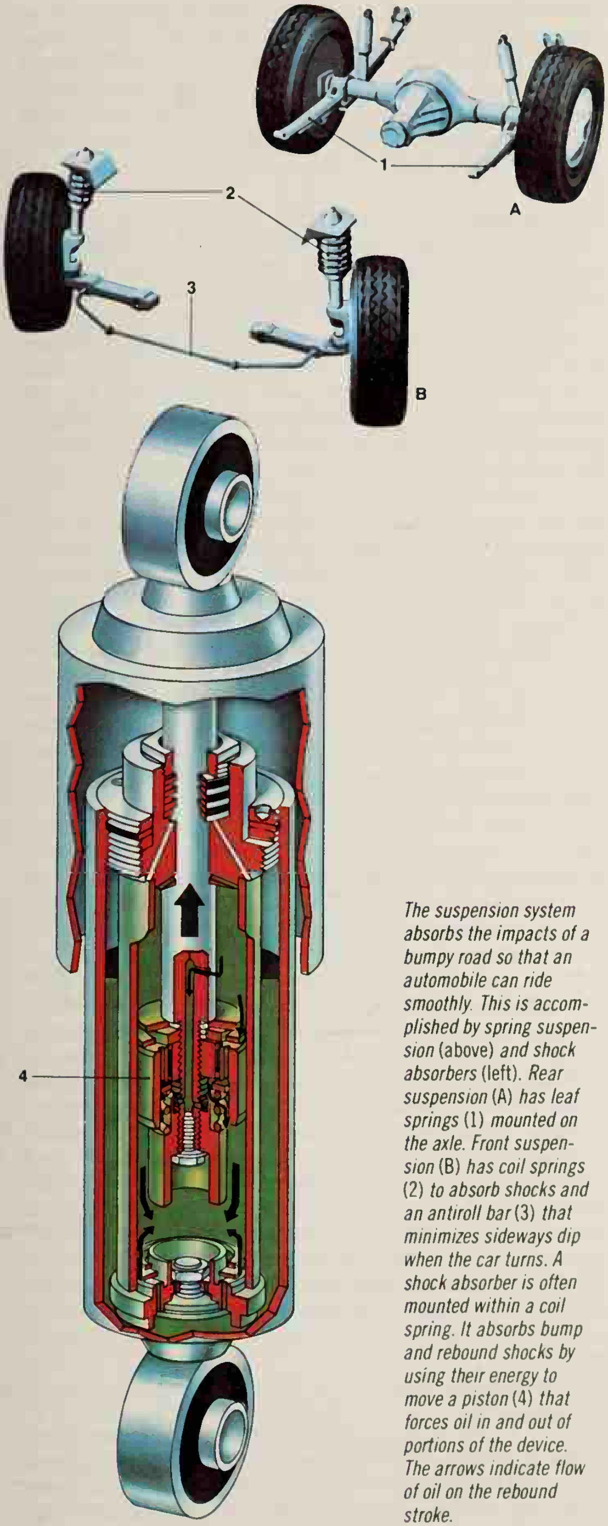
suspense fiction see MYSTERY, SUSPENSE, AND DETECTIVE FICTION

suspension In chemistry, a suspension is a mixture in which a liquid or a gas contains a finely divided solid that spontaneously settles as a result of gravity. The rate of settling depends on the particle size and the difference in the densities of the suspended solid and the suspension medium; the rate may be increased by centrifugation. A suspension differs from a SOLUTION because in the latter the solute is subdivided into molecules or ions, which are kept from settling by thermal molecular motion. Between suspensions and solutions lies the COLLOIDAL STATE; no clear distinction can be made between fine suspensions and systems of colloid particles that are close to the upper limit of the colloid range.

suspension system An automotive suspension system supports the frame and body of a vehicle, attaching them to the wheels. Its main purpose is to absorb road shocks caused by irregularities in the road surface in order to reduce the bumps transmitted to the occupants. The system also improves safety and road-handling ability by maintaining better contact between the wheels and the road.

Most modern motor vehicles have separate springs at each wheel, with supports arranged in several ways. There is a shock absorber at each wheel to help smooth out spring action. Different arrangements are often used for the suspension at the front and rear of the vehicle, because the front wheels must pivot from side to side for steering as well as up and down to absorb road shocks. Some cars use a torsion bar, which is a special type of spring. Stabilizers are sometimes used to prevent excessive lean-out on turns. The following four sections will describe these four parts, in turn.

Springs. A spring is a device that can temporarily store energy. By doing this it can supply energy afterwards, as in a watch or a wind-up toy; or a spring can maintain pressure between surfaces and thus support one surface from another, as in the automotive suspension system. By maintaining a constant pressure the spring not only offers support, it also resists any motion that would tend to change the position of one surface with respect to another, supplying a restoring force. Many suspension systems use coil, or helical, springs. Rear suspensions often use leaf springs. A leaf spring is essentially a flat bar that resists motion. The two ends of the leaf spring are attached to the frame, and the center is attached to the axle housing. This enables the wheel and housing to move up and down with respect to the frame when the car hits a bump in the road.



The suspension system absorbs the impacts of a bumpy road so that an automobile can ride smoothly. This is accomplished by spring suspension (above) *and shock absorbers* (left). *Rear suspension* (A) *has leaf springs* (1) *mounted on the axle. Front suspension* (B) *has coil springs* (2) *to absorb shocks and an antiroll bar* (3) *that minimizes sideways dip when the car turns. A shock absorber is often mounted within a coil spring. It absorbs bump and rebound shocks by using their energy to move a piston* (4) *that forces oil in and out of portions of the device. The arrows indicate flow of oil on the rebound stroke.*

Shock Absorbers. A shock absorber offers a large resistance to movement and so can quickly damp out vibrations. Its purpose in a suspension system is to moderate wheel movement and to prevent continuing vibrations after a wheel has passed over a bump. A spring without a shock absorber would continue to expand and contract for a long time, causing poor car control and a rough ride. On many front suspension systems the shock absorber is attached at the top to the frame and at the bottom to the lower control arm. In rear suspensions it is attached in a number of different ways.

The shock absorber contains a piston in a fluid-filled cylinder. It has valves that permit the fluid to flow from one side of the piston to the other as the piston moves up and down in the cylinder. The valves, however, restrain the flow of the fluid. Thus, as the piston moves up and down in the cylinder with the up-and-down movement of the wheel, the fluid flow is hampered and the motion is reduced. (The kinetic energy of the motion is dissipated as heat in the fluid.)

Torsion Bars. Some vehicles use torsion bars instead of coil springs at certain points of the system. The torsion bar twists as road irregularities are encountered. Its front end is attached to a lower control arm, and its rear end is attached to the car frame. As the lower control arm pivots up and down, the torsion bar twists more or less, behaving just like a coil spring.

Stabilizers. Some front suspension systems also use stabilizers. The stabilizer is a long steel rod that is attached at each end to the two lower control arms. Its purpose is to prevent excessive lean-out on turns. When the vehicle goes around a curve, centrifugal force tends to make the car lean out. This action puts more weight on the outer front spring, which thus is compressed more than the inner spring on the turn. As the outer spring is compressed, it imparts a twist to the stabilizer bar. The inner spring on the turn tends to expand, because it has less weight on it. This twists the stabilizer bar in the opposite direction. The stabilizer bar resists this twist and thus reduces the amount that the vehicle can lean out on a turn.

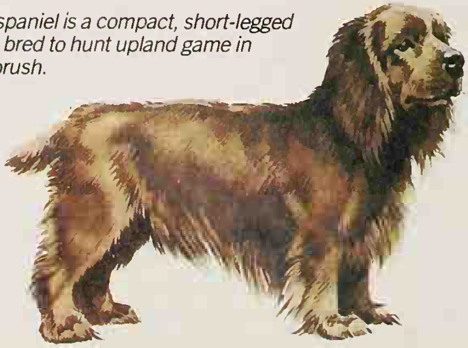
Susquehanna [suhs-kwuh-han'-uh] The Susquehanna, also sometimes called the Susquehannock, Conestoga, or Minqua, were a tribe of North American Indians who spoke an Iroquoian language and formerly inhabited a territory that now makes up southeastern Pennsylvania and northern Maryland. In the spring they planted maize, beans, and squash near their permanent villages, then moved to temporary villages on the coast where they fished and collected shellfish throughout the summer. In the fall they returned to the permanent villages to harvest their crops, collect wild plant foods, and hunt.

Characterized as a noble, heroic, and powerful people at the time of their first contact with Europeans, the Susquehanna subjugated the coastal Delaware after being pushed southward and eastward in 1580 by the encroaching Iroquois League. They were nearly annihilated (1676) by the Iroquois and subsequently relinquished their control over the Delaware. Survivors lived with the Oneida for a time and were then permitted to return to their homeland. With their population greatly reduced by warfare and disease, those who were left were converted to Christianity by the Quakers. This small group was massacred in 1763 by a mob of white men inflamed by reports of Indian aggressions in Pennsylvania.

Susquehanna River The Susquehanna, one of the longest rivers in the eastern United States, is 715 km (444 mi) long and has a drainage area of 71,400 km^2 (27,570 mi^2). Rising at Otsego Lake in central New York, the river winds southwest into Pennsylvania past Wilkes-Barre, where it joins its West Branch flowing from west central Pennsylvania. The river then widens and flows south and southeast past Harrisburg to Chesapeake Bay. Shallow and with numerous rapids, the Susquehanna is navigable only near its mouth and locally. The Wilkes-Barre–Scranton area is important for anthracite coal mining.

Sussex [suhs'-uhks] Sussex, a historic county in southern England on the English Channel, was reorganized (1974) into two counties: East Sussex, with an area of 1,795 km^2 (693 mi^2) and a population of 712,800 (1988 est.); and West Sussex, with an area of 1,989 km^2 (768 mi^2) and a population of 703,400 (1988 est.). Sussex is drained by the Adur, Arun, Ouse, and Rother rivers. Low, rolling hills known as the South Downs cross the counties from east to west. The economy is based on dairying, poultry raising, fishing, and tourism, especially at Channel resorts such as Brighton. Sussex, one of the early Anglo-Saxon kingdoms, fell to the kings of Wessex in the 9th century. The Battle of Hastings in 1066 took place in Sussex.

Sussex spaniel The Sussex spaniel was developed at the end of the 18th century in Sussex, England, when the need arose for a substantial hunting dog for rough terrain. Among the rarest purebred dogs, the Sussex has a good nose but not the speed of springer and cocker spaniels and is more massive than most spaniels. The breed's most distinctive trait is the color of its straight or slightly wavy coat: a solid rich golden liver. The dog stands 38 to 40 cm (15 to 16 in) high at the shoulder and weighs 18 to 20 kg (40 to 45 lb). The head is large, as are the ears, which are carried flat against the side of the head. The tail is set low and docked 13 to 18 cm (5 to 7 in). The coat is abundant, with feathering on the legs, ears, and tail.



The Sussex spaniel is a compact, short-legged sporting dog bred to hunt upland game in thick underbrush.

Sutherland [suhth'-ur-luhnd] Sutherland is a mountainous former county in northern Scotland. Sheep raising is the main economic activity, but coal mining, whiskey distilling, and food processing also take place.

The original inhabitants, Picts, were conquered by Norse invaders in the 9th century. In the early 19th century, thousands of tenant farmers were evicted to make way for sheep farming. Dornoch served as the county town until the 1975 reorganization of local government, when Sutherland became part of the Highland administrative region.

Sutherland, George U.S. Supreme Court Justice (1922–38) George Sutherland, b. Buckinghamshire, England, Mar. 25, 1862, d. July 18, 1942, immigrated (1863) to Utah Territory as a child and became (1883) an attorney. In 1905, Sutherland was elected Republican U.S. senator from Utah and remained in the Senate until 1917. During Franklin Roosevelt's presidency, Justice Sutherland was dubbed—along with three other conservative justices—one of the "Four Horsemen" of the Court for the strong stands he took against much New Deal reform legislation.

Sutherland, Graham Graham Vivian Sutherland, b. Aug. 24, 1903, d. Feb. 17, 1980, was an English painter and printmaker. His early work is characterized by the kind of pastoral vision usually associated with Samuel Palmer, as is visible in his etchings *Pecken Wood* (1925) and *Lammas* (1926). Later, he developed this style into a more personal vision, exemplified by the etching *Pastoral* (1930). From this time until about 1945, Sutherland's work—by then mainly painting—was dominated by landscape, which he saw with the minute vision of a romantic.

After 1945, Sutherland worked primarily on religious subjects, themes derived from natural forms, and portraits. Although controversy has surrounded his portraits, the best of them, for example, that of Somerset Maugham (1949; Tate Gallery, London), are brilliant. His studies for the Maugham portrait have many of the elements present in his landscape painting. His religious subjects include a tapestry (1952–58) for Coventry Cathedral.

Sutherland, Joan One of the leading sopranos of her generation, Joan Sutherland, b. Sydney, Australia, Nov. 7, 1926, is especially noted for her interpretations of Donizetti's *Lucia di Lammermoor* and Bellini's *Norma*. The individual timbre of her voice and its unusual volume make her brilliant coloratura abilities all the more impressive. Sutherland studied at the Sydney Conservatory and made her debut at Covent Garden in 1952. In 1959 she sang her first Lucia at Covent Garden and began reviving the long-neglected bel canto operas of Donizetti and Bellini. Her U.S. debut took place in Dallas, Tex., in 1960 in Handel's *Alcina*. She appeared frequently with the Metropolitan Opera until her retirement in 1990.

Sutherland Falls Sutherland Falls, on the Arthur River, in the southwestern corner of South Island, New Zealand, are the fifth highest falls in the world. Consisting of three cataracts, they spill 580 m (1,904 ft) from the glacially formed Lake Quill, in Fiordland National Park.

Sutlej River [suht'-lej] The Sutlej River, the longest river of the Punjab, is approximately 1,450 km (900 mi) long. Beginning at an elevation of about 4,570 m (15,000 ft) in southwestern Tibet, it flows northwest and west through deep gorges in the Himalayas, across northern India, and southwest through eastern Pakistan to the Chenab River. The two join for about 80 km (50 mi) as the Panjnad River, before entering the INDUS. Dams on the river in India provide hydroelectric power and irrigation waters. The major city on the Sutlej is Ludhiana, India.

suttee [suh-tee'] Suttee, the self-immolation of the widow on her husband's funeral pyre, was a FUNERAL CUSTOM among Indian Hindus until it was abolished (1829) by the British. Sporadic instances of suttee persisted, however, into the 20th century. The act was supposedly voluntary and was intended to prove the wife's devotion and to ensure the continued union of the couple in the afterlife. In fact, suttee permitted the division of the husband's property without the complicating presence of his wife.

Sutter, John Augustus [suht'-ur] The California pioneer John Augustus Sutter, b. Johann August Suter in Germany, Feb. 15, 1803, d. June 18, 1880, gained fame when gold was discovered on his property in 1848. He immigrated to the United States in 1834, and in 1839 the Mexican governor of California gave him a large grant of land in the Sacramento Valley. There, Sutter established the colony of Nueva Helvetia, which became a center for trappers, traders, and settlers. On Jan. 24, 1848 James Wilson MARSHALL discovered gold on Sutter's land; in the GOLD RUSH that followed, Sutter's property was soon overrun by fortune hunters. The U.S. Supreme Court declared the title to much of his land invalid, and he died bankrupt after unsuccessfully petitioning Congress for payment for his losses.

Suttner, Bertha von [zut'-nur] An Austrian author of numerous antiwar novels and a tireless worker for world peace, Bertha von Suttner, b. June 9, 1843, d. June 21, 1914, was influential in Alfred Nobel's decision to establish the celebrated Nobel Peace Prize, of which she was the first female recipient (1905). The title of her major work, *Die Waffen nieder* (1889; trans. as *Lay Down Your Arms*, 1905), also became the name of her celebrated pacifist journal (1892–99). Von Suttner organized and headed the Austrian Society of Peace Lovers.

Sutton Hoo ship burial [suht'-uhn hoo] The Sutton Hoo ship burial, one of the most spectacular and important archaeological discoveries ever made in Great Britain, is located on a heath about 13 km (8 mi) northeast of Ipswich in Suffolk, England. It was discovered (1939) under the largest of more than a dozen Anglo-Saxon BARROWS (burial mounds). The ship buried at Sutton Hoo was a clinker-built vessel approximately 24 m (79 ft) long and 2.5 m (8 ft) in the beam; the ship's outline could only be detected in the sand from the innumerable iron rivets and clamps that had bound it together. The manner of burial recalls that of the famous Scandinavian ship burials, as well as the description of the burial of the Danish King Scyld Scefing in the Anglo-Saxon poem *Beowulf*.

Although no body was found in the Sutton Hoo ship, chemical analysis suggested that there had at one time been a corpse. Grave-goods found in the ship include items of Swedish, Coptic, Byzantine, and Celtic artisanship. Dating of the burial is largely dependent upon the 37 Merovingian gold coins unearthed at the site, which probably were accumulated between the years AD 620 and 630. Several experts have argued that the tomb may be that of Raedwald, king of the East Angles and high king of the Anglo-Saxons, who died *c*.625.

Suva [soo'-vah] Suva, the capital of Fiji, has a population of 69,665 (1986). Located on Viti Levu Island, Suva is the home of the University of the South Pacific (1968). Its free-port status attracts tourists, and some light manufacturing takes place. Founded in 1849, Suva was an Allied base during World War II.

Suvorov, Aleksandr Vasilievich [soo-vaw'-ruhf] Generalissimo Prince Aleksandr Vasilievich Suvorov, b. Nov. 13 (N.S.), 1729, d. May 6 (N.S.), 1800, was the greatest of the military leaders under CATHERINE II and one of Russia's foremost military heroes. He fought in the Seven Years' War (1756–63), the suppression of the Polish revolt (1768), and the First Russo-Turkish War (1768–74). Suvorov's greatest victory came in the Second Russo-Turkish War (1787–92) when he captured Ismail, one of the strongest fortifications in Europe, in 1790. He also served as military commander of the Crimea before its annexation in 1783, and his Polish campaigns in 1794 set the stage for the Third Partition of Poland (1795). The outspoken Suvorov was exiled to his estates on the accession (1796) of Emperor Paul I, but he was recalled in 1799 to lead Russian troops, in alliance with the Austrians, in the FRENCH REVOLUTIONARY

Wars. Although he drove the French from northern Italy, his campaign ended in disaster in Switzerland. Suvorov, old, sick, and disappointed by lack of Austrian cooperation, returned to Russia.

Suwannee River [swah'-nee] The Suwannee River, which rises in Okefenokee Swamp in southeastern Georgia and flows southwest across northern Florida to the Gulf of Mexico, is approximately 400 km (250 mi) long. The area near the river has cotton and tobacco plantations. The lower 230 km (145 mi) is navigable.

Suzhou (Soochow) [soo-zhoo] Suzhou is a city of 720,000 inhabitants (1987 est.) in southern Jiangsu province, China. It lies on the Grand Canal, about 85 km (50 mi) west of Shanghai, with which it is linked by a railroad. The city's silk industry, established in the 12th century, dominates the economy. Founded in the 6th century BC, Suzhou has always been noted for its beauty. Because of a maze of waterways and canals and numerous scenic gardens with temples, it is sometimes called the Venice of China and City of Gardens.

Suzuki, D. T. [soo-zoo'-kee] Daisetsu Teitaro Suzuki, b. Oct. 18, 1870, d. July 12, 1966, was a Japanese scholar, teacher, and writer known primarily as a popularizer of Zen Buddhism in the West. As a young man he studied English and Zen in Japan and in 1897 went to the United States, where he translated Buddhist texts and wrote on Mahayana Buddhism. Upon returning to Japan he began teaching (1921) at Otani Buddhist University in Kyoto, where he founded the journal *Eastern Buddhist* and wrote some of his most significant works on Zen, which emphasized the importance of experience in that religion. From 1950 until his death Suzuki traveled widely, lecturing at European and U.S. universities. He continued to write on Zen but also became interested in comparative religion, mysticism, and psychoanalysis.

Svalbard [svahl'-bahrd] Svalbard, a Norwegian dependency, consists of a cluster of glaciated islands in the Arctic Ocean, lying about 645 km (400 mi) north of Norway. The population is 3,942 (1986 est.). The Spitsbergen group within Svalbard is composed of five major, as well as many smaller, islands. The dependency's total land area is 62,049 km^2 (23,957 mi^2). Longyearbyen on West Spitsbergen, the largest island, is the administrative center. The islands lie far north of the Arctic Circle, but vegetation can survive near the coasts. Svalbard has deposits of copper, iron ore, phosphate, and zinc, but coal remains the sole exploited mineral.

Svalbard, first sighted in 1194, was reached by Willem Barents and Jacob van Heemskerck in 1596. It was a whalers' base in the 18th and 19th centuries. In 1899, Russians began extracting coal. A 1920 League of Nations treaty awarded the islands to Norway, but mineral rights were granted to Denmark, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom, and the United States. In 1925 the USSR was included in the agreement. Svalbard was a base for Arctic explorations. During World War II, British, German, and Norwegian forces occupied the islands at various times.

Sverdlovsk [svird-lawfsk'] Sverdlovsk is the capital of Sverdlovsk oblast in the Russian republic of the USSR. It is the largest city of the Urals industrial region, with a population of 1,367,000 (1989). An important industrial and transportation center, Sverdlovsk specializes in the manufacture of heavy machinery and industrial equipment, producing equipment for the iron, steel, and chemical industries and turbine generators for power stations. The city is an important training center for engineers for the Urals industrial region. Ural State University (1920) is there.

Sverdlovsk arose in 1721 around an ironworks and fort, and was called Yekaterinburg, for Catherine I, the wife of Peter I. Because of its favorable location at the junction of roads, the settlement grew into the administrative center of the Urals mining district along the main route to Siberia. After the Bolshevik revolution, during which the last tsar, Nicholas II, and his family were executed (1918) there, Yekaterinburg was renamed in 1924 for Yakov Sverdlov, an early Bolshevik who led an underground group there in 1905.

Sverdrup, Otto Neumann [svair'-druhp] Otto Neumann Sverdrup, b. Oct. 31, 1854, d. Nov. 26, 1930, was a Norwegian Arctic explorer. He captained the *Fram* when it was frozen in polar ice for nearly three years (1893–96)—drifting for about 1,600 km (1,000 mi)—for purposes of Arctic research. He again commanded (1898–1902) the ship through the Canadian Arctic and undertook three additional Arctic expeditions. The Sverdrup Islands are named for him.

Sverre, King of Norway [svair'-e] Norway's King Sverre, b. *c.*1150, d. Mar. 9, 1202, revolutionized the government and society of medieval Norway. Born in a time of civil war, he was raised as a commoner and educated for the priesthood. When told that he was the illegitimate son of King Sigurd, he fought for the throne and in 1184 was acknowledged as sole king. Sverre created a new nobility and replaced an aristocratic administration with royal officials. His firm hand in ruling the church led Pope Innocent III to excommunicate him and lay Norway under interdict.

Svyatoslav I, Duke of Kiev [svyah'-tuh-slaf] Svyatoslav I, d. 972, Varangian duke of Kiev (945–72), strove to unite the Dnepr, lower Volga, and lower Danube regions and to control trade around the Black and Caspian seas. By 965 he had conquered the Khazars between the Volga and the Don. At Byzantine bidding, he defeated (967) the Bulgars but then refused to step aside. After being defeated by a Byzantine force in 971, he was killed by the Pechenegs.

Swabia [sway'-bee-uh] Swabia, a historic area of southwestern Germany, extends from the Black Forest to the Iller River, and from Franconia south to Switzerland. It lies chiefly within the present German states of Baden-Württemberg and Bavaria. Swabia's importance was derived from its strategic location between the upper Danube and the upper Rhine rivers.

The Romans brought the area within their empire as the Agri Decumates. The Alamanni and Suevi (see GERMANIC PEOPLES) seized it during the great migrations of the 5th century AD, and it became known as Alamannia; the later name, *Swabia*, was derived from *Suevi*. The area passed (*c*.500) into control of the Franks, and by 900 it emerged as one of the German tribal duchies. The HOHENSTAUFENS were the most eminent of its dukes; the extinction of their male line after 1268 contributed to Swabia's fragmentation, after which the Zähringen, Hohenzollern, and Habsburg families owned segments. The margraves of Baden along the Rhine and the dukes of Württemberg around Stuttgart gradually became dominant. In 1806, Napoleon I made Württemberg a kingdom; along with Baden (which became a grand duchy) the kingdom survived until the end of World War I.

Swahili The Swahili are not an ethnic unit but the coastal dwellers of a number of East African countries. They speak dialects of the Swahili tongue, structurally a Bantu language but with many borrowings from Arabic. The name *Swahili*, derived from an Arabic word meaning "coast," can be applied to nearly half a million East Africans whose culture, trading economy, and language developed with the spread of Islam after Arab traders arrived among them about AD 500. The language is a lingua franca across East Africa to Zambia and the Congo and in places as distant as south Arabia, the Persian Gulf, and even the coast of Pakistan.

See also: AFRICAN LANGUAGES.

swallow The approximately 75 species of swallows in the family Hurundinidae are relatively small, delicate, insect-eating birds found worldwide except in Australia and New Zealand and on some small islands. Several species of martins are classified in the same family.

Swallows range from 10 to 23 cm (4 to 10 in) in length. The wings are long, the neck relatively short, and the body slender; the feet are small and apparently weak, but the claws are well developed. Although the bill is small, the mouth has a wide gape, which is effectively used to capture insects in the air. In contrast to the swifts, which they somewhat resemble, swallows have facial bristles near the mouth that enhance their ability to catch flying prey. The predominant colors are reddish brown, black, and white. The plumage in some species exhibits a green or purple iridescence. The outward appearance does not usually vary between sexes.

Swallows are agile fliers with much endurance and maneuverability. Many are colonial, and large flocks may develop at the time of migration. Nests contain three to seven eggs and may be built in sandbanks, on cliffs, in tree cavities, and on or in buildings. In addition, some species make extensive use of man-made martin houses.

The barn swallow, the most common of all swallows, is found almost worldwide and in all sorts of environments. It migrates vast distances, and it is not unusual for birds to fly from Scandinavia to southern Africa, traveling up to 960 km (600 mi) in a day.

swamp, marsh, and bog Wetlands are areas, other than lakes or rivers, whose soils are saturated with water for indefinite or prolonged periods of time. Often these wetlands result from the surface exposure of GROUNDWATER, that is, the water that has percolated down through the soil and accumulated and built up on a layer of rock or other impervious material. The upper boundary of the groundwater, called the WATER TABLE, rises or falls as the amount of groundwater varies. Swamps, marshes, and bogs are wetlands in which the water table is at, near, or above the surface of the land. Plant growth in these areas is limited to species that can withstand having their roots submerged for long periods of time.

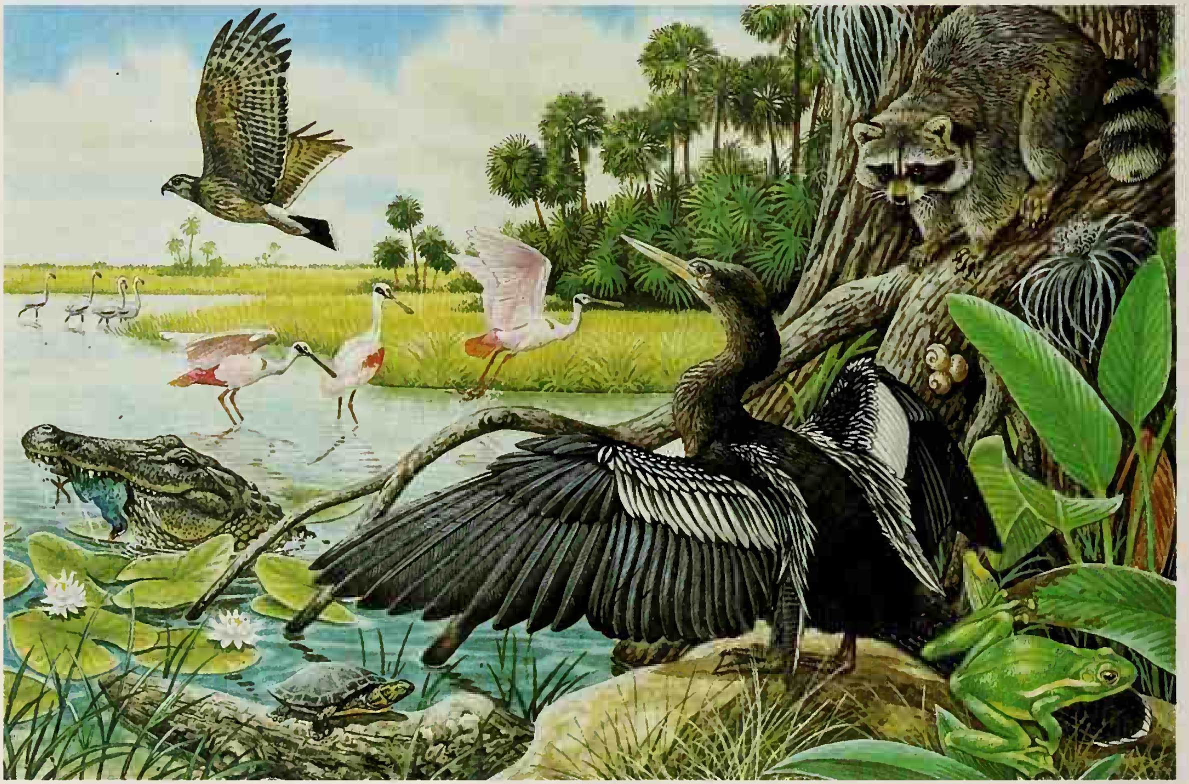
Depending on many factors, including climate, mineral content, and the permanency of surface water, wetlands may be mossy, grassy, shrubby, or wooded. Conventionally, a swamp is a wetland whose soil is permanently or protractedly saturated with water and whose vegetation is dominated by woody plants, such as trees. A marsh is similar, but its dominant vegetation is herbaceous, consisting of such plants as grasses or sedges. A bog is a wetland that appears relatively dry, with only small amounts of shallow water visible, but its ground surface is spongy and wet to the touch.

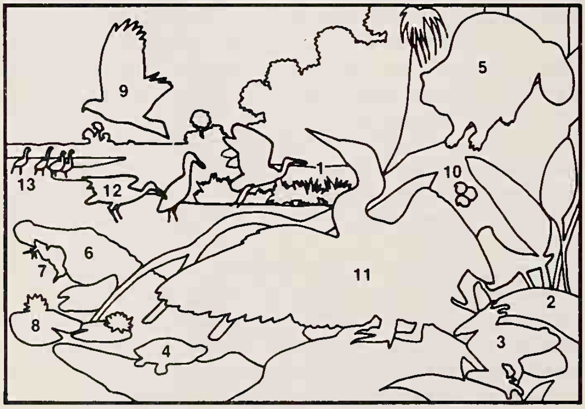
This terminology is not precise: what one locality might call a bog, another might refer to as a swamp or a marsh. Additionally, all three types of wetlands may be present and closely associated in one area. Intergradations also occur. A northern boggy area may support trees—such wetlands are known as muskegs. In Britain, boggy areas may be referred to as moors or heaths, and a grassy marsh may be called a fen.

Marshes

Flora. A characteristic of marshes is the absence of trees and shrubs; marsh plants tend to be soft-stemmed or herbaceous. Marshes often include areas of open water surrounded by plants such as cattails, rushes, arrowheads, pickerel weed, and bur-reed, all of which grow with their stems and leaves partly submerged. Water lilies are rooted in the bottom, with their leaves floating on the surface. Floaters, such as the duckweed, water lettuce, and water hyacinth, are more restricted in distribution; some occur only in the open waters of southern marshes and swamps. Submerged aquatics such as pondweeds grow in the deep-water marshes or in the littoral zones of shallow ponds that have marshlike features.

Fauna. Animal life is highly diverse and includes an array of aquatic insects, some of which spend only their early stages in the water and then become terrestrial adults, such as dragonflies and damselflies; others are permanently bound to the aquatic medium. Frogs and





The marshlands of the Everglades, in southern Florida, are dominated by vast expanses of saw grass and dotted with low islands, or hammocks, of trees and shrubs. Plant growth in a marsh is limited to species that can withstand having their roots submerged for long periods of time. Saw grass (1) *is a sedge with sharp-toothed edges; broad-leaved thalia* (2)*, a tall (up to 3 m/10 ft) herb, grows on marshy borders of swamps. Common Everglades animals include the green tree frog* (3); *several kinds of turtle* (4); *raccoon* (5); *and American alligator* (6)*, seen preying on a purple gallinule* (7). *The gallinule often walks on water-lily* (8) *leaves to feed on seeds and insects. The everglade kite* (9) *feeds only on water snails* (10); *the anhinga, or snakebird* (11)*, hunts fish by spearing them with its sharp bill. Both birds have become rare in the Everglades because of destruction of habitat and food supply, largely as a result of the human practice of swamp drainage. The roseate spoonbill* (12) *feeds on small animals and plants by sweeping its bill from side to side in the water. The American flamingo* (13) *rarely visits the southern tip of Florida.*

turtles are common. In the Florida Everglades, alligators are especially common in the sloughs during the dry season. The anhinga, or snake bird, is also a familiar inhabitant of the Everglades, as are wading birds such as the great blue heron, bitterns, and egrets. Muskrats frequent cattail marshes, where they feed on the roots of the plant.

Soil. Because marshes are so biologically productive, several tons of dead plant and animal material become available to the food chain each year. Most of this energy-rich matter, or biomass, is broken down by bacteria and water fungi. Marshes are usually relatively shallow depressions with an organic-silt or muck-type soil forming a relatively shallow layer over the underlying mineral soil or bedrock. Streams that traverse marshes deposit silt and aid in the filling process. Wetlands that fill in may become sedgy tussock marshes or wet meadows and may eventually develop into swamps dominated by wetland trees and shrubs. If the water table remains high, however, the marsh will persist.

Salt Marshes. Tidal or salt marshes are restricted to temperate coastal areas. They occur from the intertidal zone to slightly above high tide. Here *Spartina*, or cord grass, tends to dominate, forming extensive grassy swards. Salinity and duration of flooding are among the complex of factors that determine the belting pattern or mosaic of vegetation types found in tidal marshes. Marsh snails, ribbed mussels, fiddler crabs, and amphipods are conspicuous among the animal life. Salt marshes are an important waterfowl breeding habitat, as are freshwater marshes. Marshes around the world are recognized as "duck factories," serving as breeding and feeding areas and resting places on the long migration routes of these birds (see INTERTIDAL LIFE).

Swamps

Flora. Swamps are dominated by woody plants. In the northeastern United States, red maple is a distinctive swamp tree; in the southeastern United States, the bald cypress and gums are dominant. In shrub swamps, willow, alder, or buttonbush can form pure stands. Forested wetlands often show a vertical stratification in vegetation structure, with tree, shrub, and herbaceous layers. Shrubs such as high-bush blueberry, swamp azalea, spicebush, and sweet pepperbush may form a continuous stratum. Beneath the shrubs, skunk cabbage may be an important ground cover, along with a diversity of showy species, including the purple-fringed orchid, cardinal flower, jewelweed, and marsh marigold.

Fauna. Many of the animals that inhabit marshes also live in swamps; additions include the raccoon and beaver. Wood ducks are a distinctive species in swamp forests, because they depend on hollow trees for nesting sites.

Soil. Swamp soils are relatively shallow organic-silt muck-type materials, with the mineral soil near the surface. These wooded wetlands tend to persist; however, with continuous organic filling and lowering of the water table, some upland species may become associated.

Bogs

Bogs are a distinctive wetland type, usually characterized by evergreen trees and shrubs and underlain by deep PEAT deposits. Bogs will develop in former glacial lakes by the gradual accumulation of organic matter falling from beneath a floating mat of vegetation advancing out over the water. Peat deposits 6 to 12 m (20 to 40 ft) deep are not uncommon.

Flora. Northern bogs are dominated by black spruce and larch and a shrub layer of evergreen heaths: leatherleaf, bog rosemary, bog laurel, and Labrador tea. In southern bogs, white cedar is the characteristic tree. The floating vegetation mat is often composed of sphagnum moss or sedges in which the bog orchid and two insectivorous plants, the pitcher plant and the sundew, are common.

Fauna. Animal life is often somewhat less abundant in bogs than in swamps and marshes. Amphibians, however, are associated with bogs. The bog lemming is another distinctive species of such habitats.

Preserved Human Remains. Human bodies have been found well preserved after 2,000 years in Danish bogs. Such excellent preservation is possible because most bogs are extremely acidic and low in oxygen, and therefore such organisms as bacteria have difficulty breaking down organic matter.

Fossil Record. Bog peat represents a time capsule of vegetation history. Pollen grains deposited in peat as it accumulates over the years become microfossils that record the history of upland vegetation during the 12,000–15,000 years since the last glaciers of the Ice Age receded (see POLLEN STRATIGRAPHY).

Ecological Role

Wetlands, widely recognized for their high productivity of waterfowl and wildlife, are also vital in flood control and water storage and frequently recharge the water table. Wetland plants can absorb excess nitrogen and phosphorus from sewage effluent; in many areas, wetlands filter the pollution from faulty home sewage systems. Valuable wetlands are lost to agriculture and commercial development. In the United States the protection of wetlands depends largely on federal authorities to coordinate regional programs for the conservation of these sensitive environments.

swamp eel Swamp eels (family Synbranchidae) constitute about eight species of eellike fishes unrelated to true eels. They are 30–150 cm (1–5 ft) long and lack paired fins. One species has well-developed gills; the others have small gills and gulp air, which is absorbed by a network of blood vessels lining the mouth, air bladder, or intestine. Swamp eels are found in fresh and brackish tropical waters.

swan Swans are large, long-necked aquatic birds with short legs and webbed feet. They belong to the family Anatidae, along with the duck and goose. Swans are most closely related to geese, both groups differing from ducks anatomically and in the absence of bright or metallic colors in their plumage. The most ducklike swan, the coscoroba, *Coscoroba coscoroba*, of South America, is

The whistling swan reaches nearly 1.5 m (5 ft) in length. It nests in Alaska and northern Canada and is often seen migrating in V-shaped flocks of several hundred birds.

white with black wingtips. The black-necked swan, *Cygnus melanocoryphus,* also of South America, has a black head and neck, and a red knob at the top of its blue bill. The all-white mute swan, *Cygnus olor,* of Eurasia, has been domesticated and introduced into North America, Australia, New Zealand, and South Africa; it is a familiar resident of parks and zoos. The most common species native to North America, the whistling swan, *Cygnus columbianus,* has a black bill and nests north of the Arctic Circle (some ornithologists use the genus *Olor* for some *Cygnus* species, including this one). The other North American trumpeter swan, *Cygnus buccinator,* formerly nested throughout the continent, but excessive hunting in the 19th century has limited it to scattered areas. Bewick's swan, *Cygnus bewickii,* is the Old World counterpart of the whistling swan, and the larger whooper swan, *Cygnus cygnus,* of Eurasia, is the counterpart of the trumpeter.

Swans feed mainly on aquatic vegetation. Their strong bills have serrated edges and a nail at the tip, and the surface of the tongue is spinous, all of which aid in grasping and tearing plants. Horny serrations in the bill help in filtering small food items from the water surface, but swans most often feed from the bottom of ponds. Swans generally mate for life, with both sexes building the nest and caring for the young.

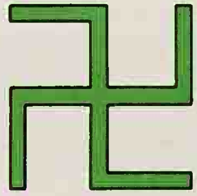
Swansea [swahn'-zee] Swansea, a coastal city in West Glamorgan, South Wales, has a population of 186,199 (1981). In the 19th and early 20th centuries the city's primary industry was metal smelting, using local coal. By the 1970s, however, petroleum refining and petrochemicals had become dominant. Port facilities have been modernized to handle exports of refined petroleum and general cargo. The University College of Swansea (1920) is located there. Probably settled by the Danes in post-Roman times, Swansea was chartered in the 12th century. The city center was rebuilt after heavy German bombing in 1941.

Swanson, Gloria [swahn'-suhn] The personification of glamour and prodigality in Hollywood's silent era, Gloria Swanson (stage name of Josephine Swenson), b. Chicago, Mar. 27, 1898, d. Apr. 4, 1983, starred in such Cecil B. De Mille spectaculars as *Male and Female* (1919) and *The Affairs of Anatol* before founding (1927) her own production company, for which she made *Sadie Thompson* (1928). Her career foundered in the 1930s, but she made a brilliant comeback in *Sunset Boulevard* (1950); subsequently she appeared in *Airport 1975* (1974) and frequently on television.

Swarthmore College [swohrth'-mohr] Established in 1864 by the Quakers, Swarthmore College is an independent coeducational liberal arts school in Swarthmore, Pa. Master's degrees are offered in some fields. Swarthmore participates in a cross-registration plan with Bryn Mawr, Haverford, and the University of Pennsylvania.

swastika The swastika is an ancient symbol of unknown origin that has been employed for thousands of years as a religious sign and a decorative emblem. It takes the form of an even cross with the arms bent in the middle at right angles; all the bars point in the same direction, clockwise or counterclockwise. The swastika appeared in ancient China, Egypt, and India. It has been found on Greek coins, pre-Christian Celtic and Scandinavian artifacts, the catacombs of the early Christians in Rome, and Byzantine buildings. The swastika was widely used by American Indians. It represented the Sun and infinity.

In the 20th century, the swastika was adopted as the emblem of the Nazi party in Germany. Mistaking its origin, the Nazis regarded it as an "Aryan" symbol and linked it to the notion of their "racial superiority." From September 1935 until the fall of the Nazis in 1945, the swastika was prominently displayed on the official flag of the Third Reich, a black swastika in a white circle against a red field. When the war ended, the Allies banned display of the emblem, which had come to be identified with the evils of Hitler's regime.



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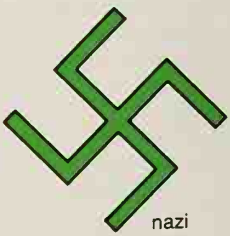


nazi

AT A GLANCE

KINGDOM OF SWAZILAND

Land: Area: 17,363 km^2 (6,704 mi^2). Administrative capital: Mbabane (1986 est. pop., 38,290). Royal and legislative capital: Lobamba. Largest city: Manzini (1986 est. pop., 52,000).

People: Population (1990 est.): 778,525. Density: 45 persons per km^2 (116 per mi^2). Distribution (1986): 77% rural, 23% urban. Official languages: English, siSwati. Major religions: Christianity, traditional religions.

Government: Type: monarchy. Legislature: Libandla. Political subdivisions: 4 districts.

Economy: GNP (1989): $683 million; $900 per capita. Labor distribution (1987): agriculture—36%; services—20%; manufacturing—14%; construction—9%; other—21%. Foreign trade (1988): imports—$386 million; exports—$394 million. Currency: 1 lilangeni = 100 cents.

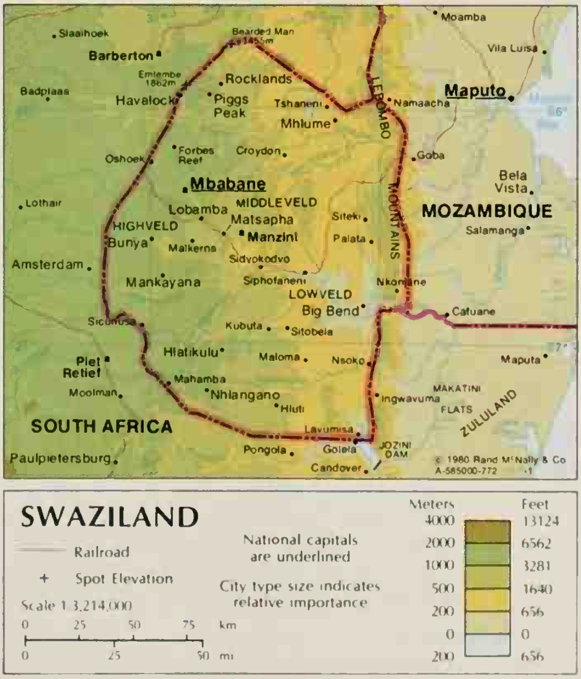
Education and Health: Literacy (1986): 67% of adult population. Universities (1990): 1. Hospital beds (1984): 1,608. Physicians (1984): 80. Life expectancy (1990): women—55; men—48. Infant mortality (1990): 126 per 1,000 live births.

Swaziland [swah'-zee-land] The kingdom of Swaziland is a small, landlocked country in southern Africa, surrounded by South Africa except for a short border with Mozambique. Formerly a British protectorate, it gained its independence on Sept. 6, 1968.

Land, People, and Economy

The western Highveld, part of the DRAKENSBERG range, is the source of several fast-flowing rivers, including the Usutu, Umbuluzi, and Ngwavuma. Here Emlembe, the highest point in the country, rises to 1,862 m (6,109 ft). Central Swaziland is gently undulating savanna, whereas the eastern Lowveld is flat and semiarid. The Lebombo Ridge, which runs along the eastern boundary, is environmentally similar to the Middleveld. Rainfall decreases from more than 1,651 mm (65 in) in the Highveld to about 686 mm (27 in) in the Lowveld. Mean annual temperatures range from 15° C (59° F) in the Highveld to 22° C (72° F) in the Lowveld.

Swaziland is rich in mineral resources, especially in the western Highveld, which contains the enormous Havelock asbestos mine, vast iron-ore deposits, and pockets of gold and tin. Rivers provide hydroelectric power and water for irrigation. Bituminous coal is mined at Mpaka; anthracite deposits have been found at Maloma. The central grasslands are suitable for grazing and growing subtropical export crops.



The Swazi, a NGUNI-speaking people, form more than 90% of Swaziland's population. English and siSwati are the official languages. The administrative capital and largest town is MBABANE. Higher education is available at the University of Swaziland (1964).

For its size Swaziland has a diversified economy, marked by pronounced social and economic dualisms. The modern sector is represented by European-controlled agricultural, forestry, manufacturing, and commercial interests. The traditional economy is characterized by subsistence cultivation, mainly of corn and millet, and by pastoralism. Sugarcane is the chief cash crop and leading export. Fruits, cotton, meat, forest products, asbestos, and coal are also exported. Manufacturing, chiefly the processing of agricultural and forest products, accounts for nearly one fourth of the GDP. Swaziland is in a customs union with South Africa, Botswana, and Lesotho. Most of its imports originate in or travel through South Africa, on which it is economically dependent.

History and Government

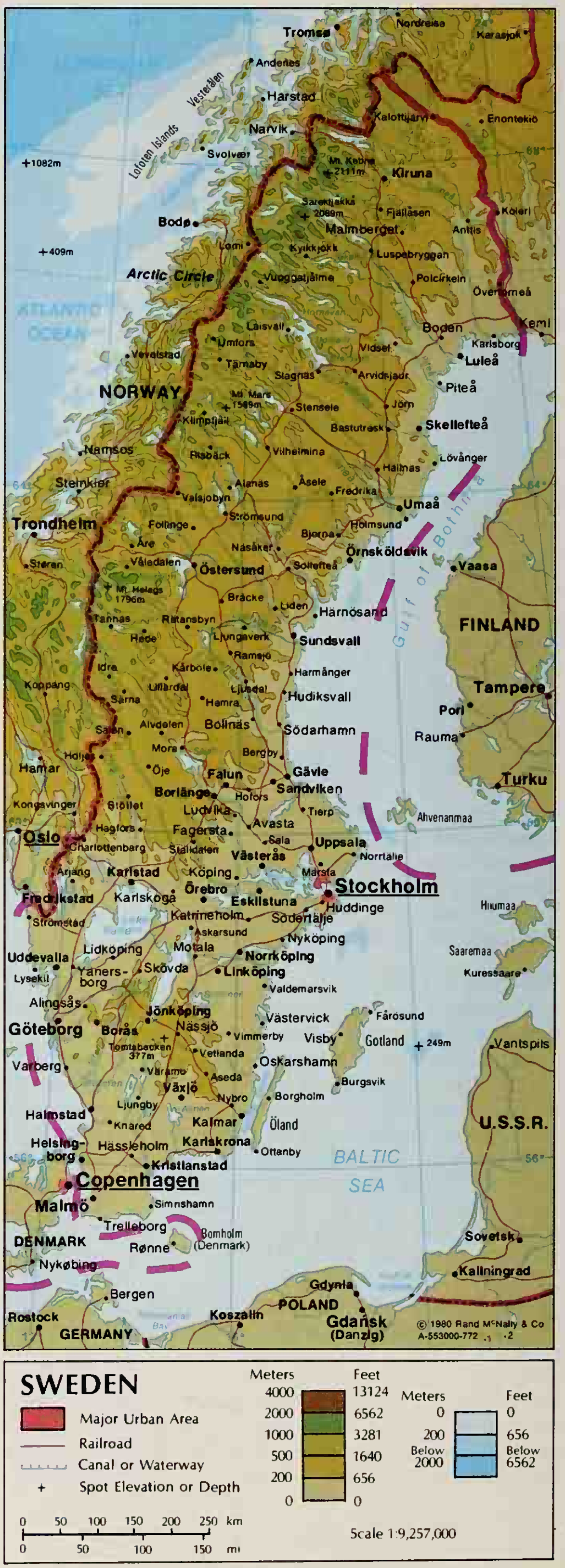
The Swazi settled the area in the early 19th century. The discovery of gold there in 1879 was followed by a great influx of Europeans, and in 1894, Swaziland became subject to the Boer republic of Transvaal. After the British defeated the Boers in the South African War, it was reconstituted (1903) as a British High Commission Territory. Swaziland regained independence in 1968 as a constitutional monarchy.

In 1973, King Sobhuza II, who reigned from 1921 to 1982, repealed the constitution and assumed absolute power. The 1978 constitution created a legislature whose members were indirectly elected or appointed by the king; all legislation required approval by the crown. After a power struggle, Sobhuza was succeeded by one of his many sons, Makhosetive, who was crowned King Mswati III in April 1986. Legislative elections were held in 1988. A 1982 attempt by South Africa to transfer the KaNgwane homeland and part of KwaZulu to Swaziland was blocked by the South African courts. In 1984 it was disclosed that Swaziland and South Africa had signed a nonaggression pact in 1982.

Sweden The largest of the five Nordic countries, Sweden forms part of Scandinavia in northwestern Europe. Stretching from north to south, Sweden shares a long land frontier with Norway to the west. Finland, the Gulf of Bothnia, and the Baltic Sea are to the east, and Denmark lies to the south across the narrow waters of the Skagerrak, Kattegat, and Öresund. The Baltic Sea islands of Gotland and Öland are integral parts of Sweden. Rich in iron ores and forest resources, Sweden is an advanced industrial nation with a high standard of living. Sweden's political unification was completed about AD 1000, and it expanded to control a large empire during the 16th and 17th centuries.

Land and Resources

Northwestern Sweden is crossed by an ancient mountain chain rising to Sweden's high point of 2,111 m (6,926 ft)



AT A GLANCE

KINGDOM OF SWEDEN

Land: Area: 449,964 km^2 (173,732 mi^2). Capital and largest city: Stockholm (1990 est. pop., 672,187).

People: Population (1990 est.): 8,527,036. Density: 19 persons per km^2 (49 per mi^2). Distribution (1985): 83% urban, 17% rural. Official language: Swedish. Major religion: Evangelical Lutheranism.

Government: Type: constitutional monarchy. Legislature: Riksdag (parliament). Political subdivisions: 24 counties.

Economy: GNP (1988): $160 billion; $19,150 per capita. Labor distribution (1988): agriculture, forestry, and fishing—4%; manufacturing—22%; construction—6%; trade—14%; transportation and communication—7%; services—32%; other—15%. Foreign trade (1989): imports—$48.5 billion; exports—$52.2 billion. Currency: 1 Swedish krona = 100 öre.

Education and Health: Literacy (1990): 100% of adult population. Universities (1986): 34. Hospital beds (1988): 55,331. Physicians (1989): 26,577. Life expectancy (1990): women—81; men—75. Infant mortality (1990): 6 per 1,000 live births.

in Kebnekaise (Mount Kebne). The remainder of the Norrland (north of about latitude 60° north) is a southeast-sloping plateau. South of the Norrland, forming the region of Svealand in central Sweden and Götaland farther south, is a varied region of plains and rift valleys that rise to a high point of only 377 m (1,237 ft) in the Southern Swedish Highlands near Jönköping. The Central Swedish Depression, a down-faulted, lake-strewn lowland extends across the peninsula from near Göteborg to east of Stockholm and Uppsala.

Soils. The entire country was covered by ice during Quaternary glaciation, and both the thin moraines and bare rocks left by the ice underlie soils of poor-to-mediocre quality. More fertile podzols are found in the Central Swedish Depression and in the coastal areas of the south.

Climate. Because of its latitudinal extent, Sweden has a number of climate regimes. A cold, maritime west coast, or northern forest (boreal), type of climate similar to that found in New England dominates the country's west coast. The northern two-thirds of the country has a continental climate marked by severe winters. The south central areas experience the long, cold winters of the north, but they enjoy milder summers. In January temperatures decrease markedly from south to north, averaging −0.8° C (30.5° F) at Lund (in the south), −2.8° C (27° F) at Stockholm, and −13.7° C (7.5° F) at Jokkmokk (north of the Arctic Circle). In July, when many hours of sunshine are recorded in the north and nearly 24 hours of continuous daylight north of the Arctic Circle, the temperature variation is minimal, ranging from an average of 15° C (59° F) at Jokkmokk, to 18° C (64° F) at Stockholm, and only 17° C (63° F) at Lund. Precipitation ranges from more than 914 mm (36 in) in exposed western mountain areas to less than 457 mm (18 in) in the extreme eastern part of Sweden. Snow remains on the ground for 40 days in southernmost Sweden, 100 days in the Stockholm area, and 250 days in the northwest mountains.

Drainage. Sweden's principal rivers originate in the northwest mountain chain and flow generally southeastward into the Gulf of Bothnia. The three largest drainage basins are those of the Göta älv, Muonio-Torne, and Ångerman river systems. Almost 100,000 lakes cover about 9% of all Sweden, a fourth of the total lake area being occupied by the four large lakes of the Central Swedish Depression—VÄNERN, VÄTTERN, Hjälmaren, and Mälaren.

Vegetation and Animal Life. Forest now covers about 55% of the land area. It consists of a summer-green forest of beeches, oaks, and other deciduous trees in the south, a mixed forest of deciduous and coniferous trees in central Sweden, and a predominantly coniferous forest of mainly pines and spruce in the Norrland. Treeless moors (peat moss and marshland) cover more than 14% of all Sweden and as much as 40% in western areas of the south and parts of Norrland. Elk and deer are the common large animals.

Resources. The most important mineral is iron ore, with deposits estimated at 2.4 billion metric tons (2.64 billion U.S. tons) in the Gällivare-Malmberget and Kiruna fields north of the Arctic Circle. Other iron-ore deposits occur at Bergslagen, located in southern Sweden northwest of Lake Mälaren. Copper, silver, lead, zinc, and arsenic occur near the Boliden area in Norrland, and some uranium deposits are found in southern Sweden. Only about 7% of the land area is suitable for farming. Abundant water resources are much used for hydroelectric power.

People

Sweden has a relatively homogeneous population in ethnic stock, language, and religion. Because of the country's isolation few non-Swedes have intermixed with the Swedes; the major groups that have done so were Finns after 1580 and Walloons from present-day Belgium, who settled in the Bergslagen area in the 1620s. Groups that maintain their distinct ethnic identity today include a growing Finnish population, about 17,000 LAPPS, and recent immigrants from Estonia, Latvia, and Lithuania (in 1944); Hungary (in 1956); and Yugoslavia, Greece, and Turkey (in the 1960s and '70s).

Language. The Swedish language belongs to the east Scandinavian branch of GERMANIC LANGUAGES. The Lapp and Finnish minorities speak their respective languages as well as Swedish. Special efforts have been made to teach Swedish to the recent immigrant groups.

Religion. More than 90% of the population are members of the State Evangelical Lutheran church, established in 1527 as the national religion. Religious freedom has been constitutionally guaranteed since 1809, and about 400,000 belong to nonconformist (free) Protestant churches. Many recent immigrants from southern Europe are Roman Catholics; some are Eastern Orthodox.

Demography. The Swedish population was 1,780,678 at the time of the first census in 1750. The urban population advanced from 21.5% of the total in 1900 to 87% in 1980, one of Europe's fastest rates of urbanization, which left much of the countryside depopulated. The three largest urban areas are STOCKHOLM, GÖTEBORG, and MALMÖ. The birthrate is one of the lowest in the world and is still declining; the overall national growth rate is about 0.4% annually, attributable mainly to immigration. Götaland and Svealand, forming the southernmost third of Sweden, are the most densely populated regions; Norrland, by contrast, has 59% of the total land area but less than one-fifth of the total population.

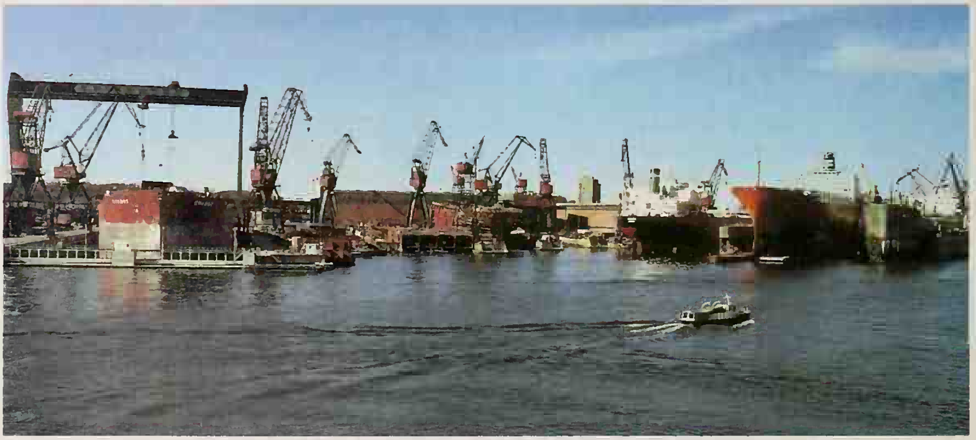
Education and Health. Education has been compulsory since 1842, and nearly all of the population is literate. All children at 7 years of age begin a 9-year basic school, followed by 2 to 4 years of gymnasium (secondary school). The oldest and largest university is in UPPSALA and dates from 1477. Health-care expenses are covered by national health-insurance and hospitalization plans and account for nearly half of all social-welfare costs.

The Arts. Leading cultural institutions are the Swedish Royal Opera; the Royal Dramatic Theater; the National Touring Theater; and the Swedish Academy, which awards the Nobel Prize for literature. Important Swedish artists are discussed in the article SCANDINAVIAN ART AND ARCHITECTURE; major literary figures, in SWEDISH LITERATURE; and composers and singers, in SCANDINAVIAN MUSIC. Sweden has made notable contributions to the art of cinema. Major Swedish directors of the silent era included Victor Sjöström (1879–1960), known in the United States as Victor Seastrom; and Mauritz Stiller (1883–1928). Later, Ingmar BERGMAN gained worldwide recognition. Swedish film stars Greta GARBO and Ingrid BERGMAN won international fame in Hollywood.

Economic Activity

Poor in agricultural resources, Sweden began trading with Russia and southeastern Europe under the Vikings (9th–11th centuries). In the Middle Ages trade expanded with other parts of Europe, and Visby (on Gotland) became the center of the Hanseatic League's thriving Baltic Sea trade in fish, timber, and metals. In the 15th century the iron ores at Bergslagen were being smelted with charcoal from the surrounding forest, and by the 17th and 18th centuries Sweden was Europe's foremost producer of high-quality steels. Lumbering developed on a large scale in the early 19th century. The Industrial Revolution reached Sweden between 1850 and 1870; its late start helped avoid the ugly urban communities associated with early industrialization in Germany, the United Kingdom, and France.

Mining. Although iron-ore production has dropped sharply in recent years, it is still an important industry.



Göteborg, Sweden's principal seaport and second largest city after Stockholm, is the center of the nation's thriving shipbuilding industry. The city is situated along the Göta River's mouth on the Kattegat.

Sweden is a major exporter of iron. The most important mining areas are located at Kiruna and Gällivare in the north, where the ores have an iron content of 60–65%. Lower-grade but more desirable nonphosphoric iron ores occur at Bergslagen. Sweden also produces copper, lead, silver, and arsenic from the Skelleftea field.

Manufacturing. About half of the people employed in manufacturing are in Sweden's metalworking establishments. Eskilstuna is known for its high-quality steels, and Sweden is a well-known exporter of such precision items as Volvo and Saab automobiles, SKF ball bearings, ASEA high-voltage cable and other electrical equipment, L. M. Eriksson electrical and telephone equipment, and Electrolux electrical appliances. The country's shipbuilding industry is the world's second largest. Chemicals and petrochemicals are growing in importance throughout the country.

Energy. Nearly half of Sweden's energy needs are supplied by nuclear power. In a major policy reversal following the 1986 Chernobyl nuclear plant accident, the Swedish parliament approved (1988) a plan to phase out nuclear power by the year 2010. Most of the remainder of the country's energy comes from hydroelectricity, generated mainly by rivers in the north.

Agriculture. Agriculture is highly mechanized. Three-fourths of all farm income is derived from livestock and dairy products. Most cultivated crops are grown primarily for fodder; the most important of these are barley, oats, wheat, and hay. Rye, sugar beets, and potatoes are also cultivated.

Forestry and Fishing. Sweden is one of the world's leading producers of timber, wood pulp, and newsprint—the annual tree cut almost equaling the yearly regrowth of the vast forests. Fishing is small scale by comparison, and a considerable portion of the fish supply is imported. A 1988 agreement with the Soviet Union defined Soviet and Swedish fishing rights in the Baltic Sea.

Transportation. Sweden's road system is well developed, even in the north. More than half of all roads are paved, and automobile and truck traffic has greatly increased since World War II. Rail traffic, on the other hand, has declined. Sweden's international airports are Arlanda (Stockholm), Landvetter (Göteborg), and Sturup (Malmö). Stockholm, Göteborg, and Malmö are the principal seaports.

Trade. About half of Sweden's trade is with members of the European Community (EC). Sweden itself has remained outside the EC because of concern that membership would compromise its traditional neutrality. The major imports are machinery and automobiles, petroleum, textile fibers, and foodstuffs. The leading exports are machinery and automobiles, wood pulp, paper and wood, and iron ore.

Government

Sweden is a constitutional monarchy with a parliamentary form of government. The present constitution was adopted in 1975, replacing that of 1809. The monarchy occupies a ceremonial and symbolic position; CHARLES XVI GUSTAV has occupied the throne since the death of King GUSTAV VI ADOLF in 1973. Legislative authority rests in the unicameral Riksdag (parliament), composed of 349 members elected to 3-year terms under a system of proportional representation. The prime minister and cabinet form the government.

Gamla Staden (Old Town), the historic center of Stockholm, covers three small islands in Lake Mälar, linked by bridges to the mainland. Several of its buildings date from the 13th century, when Stockholm was founded.

The principal political parties are the Social Democratic party (led by Ingvar CARLSSON), which has controlled the government during most of the period since 1932; the Center party (led by Thorbjörn FÄLLDIN); the Moderate Coalition party (formerly the Conservative Party); the People's party; the Communist party, or VPK; and the environmentalist Green party. The Center party, the Moderate Coalition, and the People's party held power singly or in coalition from 1976 to 1982. The Social Democrats won victories in the elections of 1985 and 1988.

History

Sweden was first populated by Paleolithic hunters during the end of the last ice age, *c.*10,000–*c.*8000 BC. During the Bronze Age (*c.*1500–500 BC) lively trade links existed with the rest of Europe. From *c.*100 BC extensive trade was shared with Rome, and in the 4th century AD Baltic trade was centered on Gotland. At this time small kingdoms were formed by tribes, the most important of which, the Suiones (Svearna) in the Lake Mälaren region, was mentioned by Tacitus in AD 98. Other tribes, the GOTHS (Götarna) in the south and the Hälsings and Lapps in the north, appear in sources from the 6th century AD. Christianity came to Sweden in the 9th century. By 1000 the Goths had been conquered by the Suiones, and the first unified Swedish state founded.

The VIKING period, from the 9th century to *c.*1050, was prosperous. In the 13th century parts of Finland and

Karelia were occupied by Swedes. Slavery ended in 1335, and the first Swedish national law was compiled about 1350. In 1397 the Danish queen MARGARET I united Denmark, Sweden, and Norway in the Kalmar Union. This union lasted to 1523 when, as opposition to the continuing aggression of Denmark and the HANSEATIC LEAGUE mounted in Sweden, Gustav Vasa used the murder of Swedish leaders in the so-called Bloodbath of Stockholm (1520) to lead a revolt against Denmark. Ruling as GUSTAV I Vasa (1523–60), he achieved independence for Sweden and introduced Lutheranism as Sweden's national religion.

Sweden's expansion continued during the 16th and 17th centuries. Estonia, Latvia, and Lithuania were occupied between 1561 and 1629. Under GUSTAV II ADOLF (r. 1611–32), Sweden entered the THIRTY YEARS' WAR on the side of the Protestants and gained lands in northern Germany (see WESTPHALIA, PEACE OF). Sweden's period as an empire (1611–1718) reached its apex under CHARLES X Gustav (r. 1654–60) but came to an end in the 18th century with the rise of Russia as a unified empire under Emperor Peter I. In the Great NORTHERN WAR (1700–21), Sweden lost its Baltic territories and several of its north German provinces on the death of CHARLES XII (r. 1697–1718). After the war an early form of parliamentarism was initiated, but this era, known as the Age of Freedom, ended abruptly in 1772 following a coup d'état by GUSTAV III (r. 1771–92) and the reestablishment of a strong monarchy.

During the NAPOLEONIC WARS, Sweden joined (1805) the Third Coalition against France. In 1809, Russia, then an ally of France, seized Finland. After this defeat GUSTAV IV ADOLF was forced to abdicate (1809) in favor of Charles XIII. In 1810, Jean Baptiste Bernadotte, one of Napoleon's marshals, was chosen by the Riksdag as crown prince. He ruled as CHARLES XIV JOHN from 1818 to 1844. Denmark was forced to cede Norway to Sweden in compensation in 1814, and Norway remained in union with Sweden until 1905.

Impoverished at the end of the Napoleonic Wars, Sweden initiated a policy of nonalignment that kept it out of World Wars I and II and began a steady and undramatic social and economic revolution within its new borders.

About 1 million Swedes emigrated to North America during the latter half of the 19th century, but emigration slowed as conditions improved after 1900. With the Social Democratic party in power for much of the 20th century (led by such notables as Hjalmar BRANTING, Tage ERLANDER, and Olof PALME), Sweden became one of the world's richest and most socially progressive nations.

Swedenborg, Emanuel The Swedish scientist, theosophist, and mystic Emanuel Swedenborg, b. Jan. 29, 1688, d. Mar. 29, 1772, pioneered in both scientific and religious thought. Swedenborg turned first to a scientific and technical career as a natural scientist and official with the Swedish board of mines (1710–45). His study of mathematics, mechanics, and physics was motivated by an interest in cosmology and finally theology, which led to his second, theosophical career as a "seer of divine wisdom." After 1734, Swedenborg turned to the study of physiology and psychology. Visited by a mystic illumination in 1745, he claimed a direct vision of a spiritual world underlying the natural sphere. His voluminous works from this period are presented as divinely revealed biblical interpretations.

Emanuel Swedenborg, an 18th-century Swedish scientist and visionary, proposed a system of relationships between natural, spiritual, and divine realms in his extensive religious works. His mystic visions and symbolic reading of the Bible became the foundation of the Church of the New Jerusalem.

In his system, best reflected in *Divine Love and Wisdom* (1763; Eng. trans., 1965), Swedenborg conceived of three spheres: divine mind, spiritual world, and natural world. Each corresponds to a degree of being in God and in humankind: love, wisdom, and use (end, cause, and effect). Through devotion to each degree, unification with it takes place and a person obtains his or her destiny, which is union with creator and creation. Unlike many mystics, Swedenborg proposed an approach to spiritual reality and God through, rather than in rejection of, material nature. His 12-volume compendium *The Heavenly Arcana* (1747–56; Eng. trans., 1951–56) represents a unique synthesis between modern science and religion. His thought influenced many transcendentalists.

In response to a vision of the "last judgment" and the "return of Christ," Swedenborg proclaimed the advent of the New Church, an idea that found social expression in the Swedenborgian societies and in the Church of the NEW JERUSALEM.

Swedish art and architecture see SCANDINAVIAN ART AND ARCHITECTURE

Swedish language see GERMANIC LANGUAGES

Swedish literature Swedish literature, although enriched by foreign influences, has never lost its national identity. Swedish writing dates back to 11th-century runic inscriptions, but the literature proper originated in the Catholic Middle Ages. Saint Bridget's 14th-century *Revelations,* written in Latin, gained fame both in Sweden and abroad. Like the religious literature, most medieval Swedish secular writings served nonliterary purposes. Exceptions were the folk ballads; more typical were legal texts in vernacular prose.

Gustav Vasa's reformation of the church contributed to a cultural decline in the 16th century. Of vital importance, though, to the development of the Swedish language were Olaus Petri's Bible translations of 1526 and 1541. During this period there also appeared Sweden's first lyric poet, the vagrant Lars Wivallius. Although Renaissance ideas never took root in Scandinavia, traces of them are seen in Georg Stiernhielm's 17th-century baroque poetry.

The 18th century, a period of enlightenment, was dominated by prose. Only toward the close of the century, during the reign of Gustaf III, did other genres emerge in the wake of French cultural influence. Noteworthy is Carl Michael Bellman's rococo poetry.

Erik Johan Stagnelius's Neoplatonism, Esaias Tegnér's and Erik Gustaf Geijer's glorification of the nation's past, and Abraham Viktor Rydberg's idealistic liberalism all reflect the philosophical orientation of Swedish 19th-century romanticism. Carl Jonas Love Almqvist, initially a mystic and romantic, came later to herald new trends of realism in his socially aware prose works. The towering figure of the century, however, was August STRINDBERG (1849–1912), Sweden's greatest writer and father of modern Swedish drama and fiction. Moving in later plays from naturalism to dreamlike symbolism, Strindberg foreshadowed expressionism.

The socially opinionated prose writers of the 1880s were succeeded by a new wave of romantics, who preferred verse and emphasized the past (Selma LAGERLÖF) and the countryside (Erik Axel Karlfeldt). About 1900, Hjalmar Söderberg published exquisite short stories set in the streets of Stockholm; but the novelists of the next decade favored small-town Sweden. Modernism was introduced in the 1920s by the Finno-Swedish poets Edith Södergran, Gunnar Björling, and Elmer Diktonius, and it was affirmed in Pär LAGERKVIST's innovative dramas and Gunnar Ekelöf's surrealistic poetry. A new social class of self-educated country writers entered Sweden's literary world in the 1930s, among them the 1974 Nobel laureates Eyvind JOHNSON and Harry Martinson.

Sweden escaped the world wars, but its literature from the 1940s (Erik Lindegren, Karl Vennberg) testifies to postwar depression. The feeling of pessimism and guilt deepened during the following decades because of the Vietnam War and Third World problems. An intense questioning of literature's social function and a mistrust of language found manifold literary expressions—from "new simplicity" and "concreteness" in poetry, to documentaries in prose. Swedish literature of the end of the 1970s, however, was characterized by a new trust in the word and a new delight in traditional fiction.

Swedish playwright August Strindberg brought colloquial realism and psychological insights to the theater. Noted for bold experimentation, he created images of despair and alienation in such plays as Miss Julie *(1888). Strindberg's later works, such as* A Dream Play *(1902), combined realism with expressionist dream sequences.*

Sweelinck, Jan Pieterszoon [sway'-link] Jan Pieterszoon Sweelinck, b. May 1562, d. Oct. 16, 1621, was a Dutch organist and composer who spent virtually his entire life in his native country and rarely left Amsterdam, where for about 45 years he held the position of organist at the Old Church. Greatly respected as a performer, Sweelinck was also a prolific composer but probably exerted his greatest influence by teaching young organists from all over Europe. His compositions for organ and harpsichord confirm his mastery of the fantasia, toccata, and variations. He also developed the style of the echo-fantasia, making use of the echo effects possible on both instruments, and did not neglect popular songs and dance themes in his variation sets. His more than 250 choral works range from French chansons to motets and psalms.

sweet fern Sweet fern, *Comptonia peregrina,* in the family Myricaceae, is a bushlike shrub found in sandy but moist soil in woodland areas and open fields of eastern North America. It commonly reaches nearly 1.5 m (5 ft) in height. The fruit is a brown nutlet. The fragrant leaves alternate and are slender. Sweet ferns are used as bank coverings and may be propagated by seeds, division, or layering.

sweet gum Sweet gums, genus *Liquidambar,* comprise six species of deciduous hardwood trees in the witch hazel family, Hamamelidaceae. There is one North American species, native to the eastern United States and found southward to Nicaragua; the others are found in Anatolia and eastern Asia. American sweet gums, *L. styraciflua,* can be distinguished by their long-stalked, star-shaped leaves, with five to seven lobes. The bark is gray or brown and deeply furrowed. The fruit, a hard ball with curved, spiny projections, opens in the autumn to release winged seeds. The American sweet gum grows to 36 m (120 ft) in height and is an important timber tree. A fragrant resin, or storax, can be obtained from all sweet gums, especially from the *L. orientalis*, of Anatolia. The storax is used commercially, for example, in soaps and perfumes.

sweet pea Sweet pea, *Lathyrus odoratus*, a climbing or nonclimbing annual herb in the pea family, Leguminosae, is grown for its range of petal colors, fragrant flowers, and long-lasting qualities. It grows only in cool temperatures. A native of Italy, it was introduced into northern Europe about 1700 and was developed genetically into strains or varieties after 1870. The original sweet pea was a climber. The nonclimbing variety was developed more recently in California.

sweet potato The sweet potato, *Ipomoea batatas*, a member of the morning glory family, Convolvulaceae, is grown for its tuberlike roots. Native to the American tropics, it is rich in vitamin A. Europeans brought back the plant to their continent in the 16th century, and it was later grown in Asia. About 4 to 5 months of warm weather are required for adequate yields. All varieties have long vines, often exceeding 3 m (10 ft). Most sweet potatoes are propagated by planting root sprouts or vine cuttings. Properly stored, roots can remain edible for 6 to 7 months.

The sweet potato plant, native to the Americas, is cultivated in temperate and tropical regions worldwide for its large edible roots.

sweet William Sweet William, *Dianthus barbatus*, is a popular annual, biennial, or perennial flowering herb in the pink family, Caryophyllaceae. It is native to Eurasia. The flowers are borne in terminal clusters that are bright colors of pink, red, white, and variations: sometimes double forms occur. The sweet William grows to 60 cm (2 ft) and is short-lived. A number of horticultural selections are available.

sweetener, artificial Artificial sweeteners are substances developed for use by persons who for medical reasons must restrict their SUGAR intake. Lacking caloric value, they are also widely used as FOOD ADDITIVES in dietetic foods and sold separately for individual use. The sweetener saccharin, developed in 1879, was later commonly used together with the cyclamates, discovered in 1937, until the latter were banned in the United States in 1970—except under prescription—as possible carcinogens. The sweetener aspartame, discovered in 1965, was approved for use in the United States in the 1980s.

Other sweeteners being developed or marketed include the sugar-derived Sucralose, 650 times sweeter than the natural substance, and acesulfam K, about 130 times sweeter. Substances derived from plants include hernandulcin, from the Mexican *Lippia dulcis*; it is 1,000 times sweeter than sugar but has a bitter taste as well. Thaumatin, from the West African berry ketemfe, *Thaumatococcus daniellii*, is still sweeter but has a strongly cloying aftertaste.

sweetleaf Sweetleaf is the common name for any of 290 species of large shrubs or trees in the genus *Symplocos* of the sweetleaf family, Symplocaceae. Native to the warmer regions of the Americas, Australia, and Eurasia, some species are grown as ornamentals. Only *S. paniculata* thrives in northern regions. This native of China and Japan produces bright, blue berries and small groups of fragrant white flowers.

Swenson, May [swen'-suhn] The American poet, May Swenson, b. Logan, Utah, May 28, 1919, d. Dec. 4, 1989, established a reputation for evocative glimpses of nature and everyday life. Her first volumes, *Another Animal* (1954) and *A Cage of Spines* (1958), revealed an almost incantatory handling of sound. Later volumes, such as *Iconographs* (1970), experimented with spatial forms. *In Other Words: New Poems* was published in 1987.

Sweyn, King of Denmark [swayn] Sweyn Forkbeard, b. *c.*960, d. Feb. 3, 1014, was the Danish conqueror of England (see VIKINGS). He succeeded his father, King Harold Bluetooth, after killing him in battle about 986. A few years later, Sweyn and OLAF I of Norway began their attacks on England, imposing the Danegeld (a form of tax) on the English in return for a specified period of peace. In 1000 he joined the Swedes in war against Olaf, who was killed. Norway was then divided between the victors. In 1013, Sweyn finally drove out the English king

Æthelred II and made himself king. He was succeeded by his sons Canute (in England) and Harold (in Denmark).

swift The bird family Apodidae in the order Apodiformes comprises approximately 70 species of birds called swifts. Swifts bear a superficial resemblance to swallows, but their closest relatives are the crested swifts in the family Hemiprocnidae. Except for New Zealand, Antarctica, southernmost South America, and oceanic islands, swifts are found worldwide.

These relatively small birds, 10 to 25 cm (4 to 10 in) in length, have an elongated, compact body and a short neck. Their wings are long and relatively narrow. The legs are short but strong. The toes can be arranged three forward and one back, two forward and two back, or all forward. The triangular bill is small, but the mouth slit is large. Most swifts are dark in color; some have white markings.

Swifts spend more time in the air than do any other birds. While in flight they feed on insects and may drink, pick up nesting material, and even copulate. Nests are placed in caves, hollow trees, chimneys, and, by a few species, in curled palm leaves.

Many swifts nest in colonies, which may include more than 2 million birds in some species. Both sexes incubate and feed a clutch that numbers between one and six. Swifts use saliva as an adhesive agent in their nests; a few species even make nests entirely out of salivary secretions. Bird's nest soup, which comes from the nests of cave swiftlets (genus *Collocalia*), is widely consumed in Asia.

Swift, Jonathan The 18th-century English satirist Jonathan Swift, b. Dublin, Nov. 30, 1667, d. Oct. 19, 1745, is most famous as the author of Gulliver's Travels (1726), the story of the adventures of Captain Lemuel Gulliver in four voyages to fictional places. The book is a satire, frequently mordant, on human nature; yet so inventive are its whimsy and fantasy that it has often been given to children.

Swift was educated at Trinity College, Dublin, and after graduation he passed most of the following ten years as secretary to the statesman Sir William Temple. He wished to enter politics but settled for the church, in which he was ordained in 1694. In 1702 he moved to England in hope of political appointment; there he published his first work, *A Tale of a Tub* (1704), a satire on corruption in religion and learning. He followed it with the *Bickerstaff Papers* (1708–09), in which he demolished the pretensions of John Partridge, a popular astrologer; he also contributed to Sir Richard Steele's *Tatler*.

In 1710 the government passed from Whig to Tory control; the Tories recognized in Swift a potent voice for their cause and made him editor of their journal, the *Examiner*. He thus became an unofficial power in English politics as well as a leading writer. Besides Steele, his friends included Alexander Pope and John Gay. His life during this period is recorded in the *Journal to Stella* (1710–13), his letters to Esther Johnson, a close lifelong friend.

Probably the most powerful satirist in the history of English letters, Jonathan Swift expressed his hatred of Britain's exploitative economic policy in Ireland by ironically suggesting in "A Modest Proposal" (1729) that his impoverished fellow Irishmen raise their children as a cash crop—for the culinary pleasure of the English.

Swift's political power ended with another change of government in 1714. His friends procured him the deanery of St. Patrick's Cathedral in Dublin, a post that carried prestige but also exiled him to Ireland, where he was to remain for the rest of his life.

The spectacle of Irish servitude in general, and in particular a scheme by one William Wood, who had received a royal patent to issue a new Irish coinage and planned to profit from debasing it, provoked Swift in 1724 to write the *Drapier's Letters,* exhorting the Irish to refuse Wood's coinage and develop their own economy. The development of Irish economy was also the topic of his last and most brilliant satire, *A Modest Proposal* (1729), in which he ironically counseled his countrymen and countrywomen to turn their children into a cash crop.

After Stella's death in 1728, Swift grew reclusive and eccentric. Attacks of vertigo, from which he had suffered occasionally in the past, became frequent; he declined into senility and in 1742 was declared unfit to manage himself.

swim bladder see fish

swimming Swimming is a competitive and recreational activity consisting of various motions that propel the body through the water. Swimming is considered by most experts to be one of the best forms of physical exercise. When practiced properly the activity utilizes most of the body's muscles and is an excellent conditioner for the cardiovascular system. Much of the wear and tear on the human body that is sometimes associated with land sports, such as running, is reduced in swimming because of the body's buoyancy in water. Physical rehabilitation therapy involving swimming is not uncommon.

International competition in swimming—as well as in its sister activity, DIVING—is governed by the Fédération Internationale de Natation Amateur (FINA). Swimming has been part of the Olympics since its modern-day inception in 1896.

History of Swimming

Swimming predates recorded history. Humans undoubtedly discovered how to swim by accident; a person probably fell into the water and struggled to shore using a dog-paddle stroke.

There exists an Egyptian hieroglyph for swimming dating from 2500 BC. The ancient Greeks and Romans made swimming an important part of their military training programs. It is believed that swimming contests were organized in Japan as early as the 1st century BC.

During the Middle Ages in Europe, swimming declined in popularity. People felt that the water was contaminated and a source of disease. Fear of the water was not universal, however, and Louis XI reportedly swam daily in the Seine.

During the early 19th century, swimming enjoyed a revival, especially in England; Lord Byron swam the Hellespont (now the Dardanelles) to prove that the mythological hero Leander could have done it. Organized competitive swimming began in England in the 1840s. In 1844 the British were surprised when two American Indians demonstrated the efficiency of a method of swimming similar to the modern crawl. The British still swam with the head above the water, a holdover from the days when people believed that the water was contaminated. An overhand stroke was introduced into England in 1873 by J. Arthur Trudgen, who had seen South American Indians using this method to swim quite fast. When the flutter kick was introduced, the modern "Australian crawl" was born, and this stroke has since become the most common and most important swimming stroke.

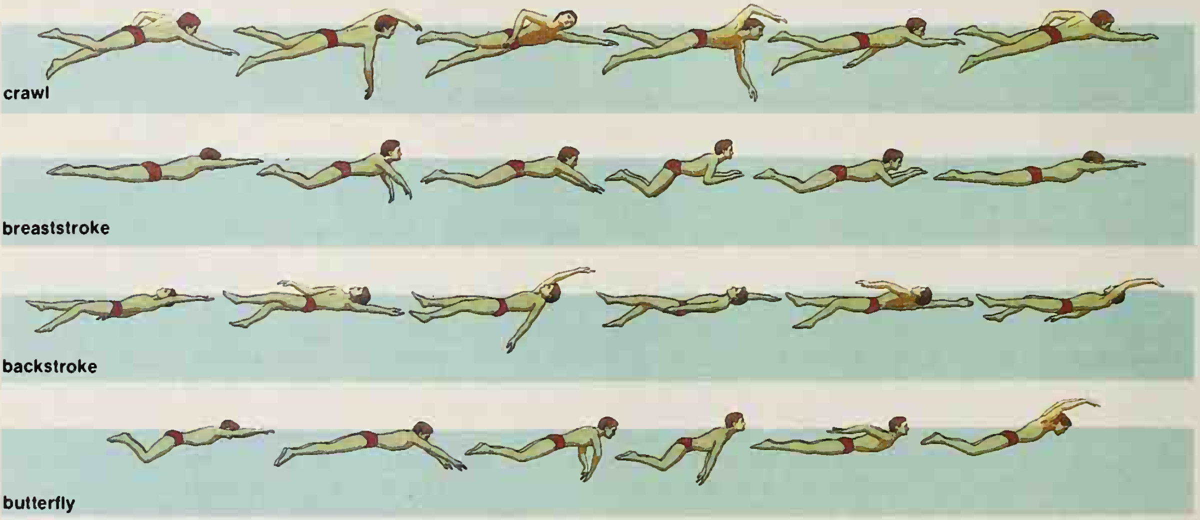
Soviet distance swimmer Vladimir Salnikov won a gold medal in the 1,500-m freestyle at the 1988 Olympics in Seoul.

Major Strokes

A variety of strokes are used in swimming, each requiring different motions. Each stroke also varies in the physical demand it places on the swimmer and the degree of speed and efficiency it offers.

Crawl. The crawl is not an official FINA-recognized stroke; in events where the contestants are allowed to swim "freestyle," the crawl is universally used. The stroke, which is performed chest-down in the water, involves carrying one arm forward out of the water to nearly

The diagram indicates four basic strokes used in competitive swimming. The crawl, combining arm-over-arm strokes with a flutter kick, is the fastest style in current use and is favored for freestyle events. To execute the breaststroke, the slowest technique, a swimmer's arms are extended forward and are swept down and back along the sides of the body. The frog kick, in which both legs are driven back simultaneously, is used. Although executed in the supine position, the backstroke is similar to the crawl in its use of a flutter kick and arm-over-arm strokes. It is the only style in which swimmers begin in the water. For the butterfly, an adaptation of the breaststroke, arms are extended forward but are raised above the water at the beginning of each stroke. Arms are pulled straight down and under the body.



WORLD SWIMMING RECORDS

Event	*Time*	*Holder*	*Date*
Men's Events			
50-m freestyle	21.38 sec	Tom Jager (USA)	Mar. 24, 1990
100-m freestyle	48.42 sec	Matt Biondi (USA)	Aug. 10, 1988
200-m freestyle	1 min 46.69 sec	Giorgio Lamberti (Italy)	Aug. 15, 1989
400-m freestyle	3 min 45.00 sec	Evgeni Sadovy (EUN)	July 29, 1992
800-m freestyle	7 min 46.60 sec	Kieren Perkins (Austrl.)	Feb. 14, 1992
1,500-m freestyle	14 min 43.48 sec	Kieren Perkins (Austrl.)	July 31, 1992
100-m backstroke	53.86 sec	Jeff Rouse (USA)	July 31, 1992
200-m backstroke	1 min 56.57 sec	Martin Zubero (Spain)	Nov. 23, 1991
100-m breaststroke	1 min 01.45 sec	Norbert Rozsa (Hung.)	Jan. 7, 1991
200-m breaststroke	2 min 10.16 sec	Mike Barrowman (USA)	July 29, 1992
100-m butterfly	52.84 sec	Pablo Morales (USA)	June 23, 1986
200-m butterfly	1 min 55.69 sec	Melvin Stewart (USA)	Jan. 12, 1991
200-m individual medley	1 min 59.36 sec	Tamas Darnyi (Hung.)	Jan. 13, 1991
400-m individual medley	4 min 12.36 sec	Tamas Darnyi (Hung.)	Jan. 8, 1991
4 × 100-m medley relay	3 min 36.93 sec	USA National Team	Sept. 25, 1988
4 × 100-m freestyle relay	3 min 16.53 sec	USA National Team	Sept. 23, 1988
4 × 200-m freestyle relay	7 min 11.95 sec	EUN Unified Team	July 27, 1992
Women's Events			
50-m freestyle	24.79 sec	Yang Wenyi (China)	July 31, 1992
100-m freestyle	54.48 sec	Jenny Thompson (USA)	Mar. 1, 1992
200-m freestyle	1 min 57.55 sec	Heike Friedrich (E. Ger.)	June 18, 1986
400-m freestyle	4 min 03.85 sec	Janet Evans (USA)	Sept. 22, 1988
800-m freestyle	8 min 16.22 sec	Janet Evans (USA)	Aug. 20, 1989
1,500-m freestyle	15 min 52.10 sec	Janet Evans (USA)	Mar. 26, 1988
100-m backstroke	1 min 00.59 sec	Ina Kleber (E. Ger.)	Aug. 24, 1984
200-m backstroke	2 min 08.60 sec	Betsy Mitchell (USA)	June 27, 1986
100-m breaststroke	1 min 07.91 sec	Silke Hoerner (E. Ger.)	Aug. 21, 1987
200-m breaststroke	2 min 25.35 sec	Anita Nall (USA)	Mar. 2, 1992
100-m butterfly	57.93 sec	Mary T. Meagher (USA)	Aug. 16, 1981
200-m butterfly	2 min 05.96 sec	Mary T. Meagher (USA)	Aug. 13, 1981
200-m individual medley	2 min 11.65 sec	Lin Li (China)	July 30, 1992
400-m individual medley	4 min 36.10 sec	Petra Schneider (E. Ger.)	Aug. 1, 1982
4 × 100-m medley relay	4 min 02.54 sec	USA National Team	July 30, 1992
4 × 100-m freestyle relay	3 min 39.46 sec	USA National Team	July 28, 1992
4 × 200-m freestyle relay	7 min 55.47 sec	E.Ger. National Team	Aug. 18, 1987

full extension, while the other arm is below the surface making a pulling movement that propels the body through the water. The flutter kick is used to add some forward thrust, but it serves mainly as a stabilizing motion. Breathing is accomplished by turning the head to one side or the other and inhaling, then turning the head so that the face is immersed and exhaling the spent air. The breathing is repeated at regular intervals in accord with the pace of the stroke.

Backstroke. The backstroke is similar to the crawl but is performed on the back and without the crawl's breathing requirement. One arm is carried over the head out of the water to prepare for the next stroke, while the arm in the water completes the forward-pulling motion. The flutter kick is used, as in the crawl.

Breaststroke. In this stroke, leg and arm movements are simultaneous. The hands are carried together forward from under the chest to full extension and are then swept back, in a lateral plane, parallel to the body, whereupon the movement is repeated. A frog kick is used: the legs are drawn up, with knees bent and each leg turned outward; the legs are then thrust back parallel to the line of the body. Both arms and legs must not move out of the lateral plane. In competition, swimmers may be disqualified for letting their strokes enter the vertical plane.

Butterfly. This stroke is similar to, and is derived from, the breaststroke. Arm and leg movements are simulta-

The person earning the most medals at Seoul was American Matt Biondi, who swam for five golds, a silver, and a bronze.

neous, although the most noticeable difference is that the arm recovery after the completion of each stroke is accomplished over, rather than under, the water. This arm movement, reminiscent of a butterfly's flight, gave the stroke its name. The legs are used in a dolphinlike kick in which they remain close together and are alternately bent and straightened out at the knee in a vertical plane. The butterfly stroke is the most physically demanding of all the major strokes.

Competitive Swimming

In competitive swimming events the winners are determined according to the best elapsed times for a particular distance. There are four basic categories of standard Olympic events. The first is freestyle—50-m (54.7-yd), 100-m (109.3-yd), 200-m (218.6-yd), and 400-m (437.2-yd) for both men and women; 800-m (874.4-yd) for women; 1,500-m (1,639.5-yd) for men; and 4 × 100-m and (for men) 4 × 200-m relay races. The second is backstroke—100-m and 200-m. The third is breaststroke—100-m and 200-m. The fourth is butterfly—100-m and 200-m. These basic categories are also combined into medley (races in which each of the four basic strokes is used by the swimmer or team in a certain sequence): 200-m and 400-m individual races and 4 × 100-m relay races.

Swinburne, Algernon Charles [swin'-burn] Algernon Charles Swinburne, b. London, Apr. 5, 1837, d. Apr. 10, 1909, was in his young manhood a shocking, and in his old age an esteemed, British Victorian poet and man of letters. At Oxford University he met Dante Gabriel ROSSETTI and other members of the Pre-Raphaelite Brotherhood, and he helped found a club known for its radical politics and religious skepticism.

An early verse drama, *Atalanta in Calydon* (1865), was favorably reviewed for its lyric passages and highly decorated narrative. The following year Swinburne published *Poems and Ballads, First Series,* which included poems spoken by sadly desperate characters who did not believe in the supernatural and were imprisoned in the limited, sometimes perverse pleasures of the physical world.

In *Songs Before Sunrise* (1871), Swinburne advanced his theme to imagine a secular redemption in which humanity will provide a meaning for existence by fully realizing its own powers. During these years, however, Swinburne grew dangerously disordered. Rescued by a friend, Theodore Watts Dunton, in 1879, he settled into a carefully managed household and career. He published 20 more volumes of poetry, criticism, and verse drama. Some of his literary criticism, especially that on Shakespeare and on the poetry of William Blake, is still vital. His late poetry is often subdued, but sometimes in poems about the sea, spring, and storms he recovered his excitement in the enlivening power of the natural world.

swine Five genera and eight species of medium-sized mammals constitute the swine family, Suidae, which first appeared in the fossil record about 40 million years ago. One species, the wild boar, *Sus scrofa*, native to Africa and Eurasia, gave rise to the domesticated PIG. The other species are the pygmy hog, *S. salvanius*, of southern Asia; the Bornean pig, *S. barbatus*, also of the Philippines; the Java pig, *S. verrucosus*, also of Celebes and the Philippines; the babirusa, *Babyrousa babyrussa*, of Indonesia; and the WARTHOG, *Phacochoerus aethiopicus*, the African forest hog, *Hylochoerus meinertzhageni*, and the bush pig, *Potamochoerus porcus*, all of Africa. Wild swine have been heavily hunted for food and sport, and several species are now endangered.

The scantily and coarsely haired, stocky bodies of wild swine range from 70 to 190 cm (27 to 75 in) in length and up to 270 kg (600 lb) in weight. The long, pointed head has a blunt, mobile snout with a cartilaginous disk at the end, used in rooting for vegetable matter; swine also eat small animals, eggs, and carrion. Each foot bears four toes, of which the middle two are hoofed; swine are grouped in the order Artiodactyla of even-toed, hoofed mammals. In some species the canines are all curved into formidable tusks. Except for the plains-dwelling warthog, swine live in thickets or forests and forage at night in small groups. Swift runners and strong swimmers, they show high intelligence. From 2 to 14 are born in a litter, depending on the species, and the average life span is 15 to 20 years.

swine fever see PIG

swine flu see INFLUENZA

swing Swing, a form of dance music played by a large band, was the medium through which most white Americans first heard JAZZ. Although the decade 1935–45 was called the Swing Era, swing arrangements had been played by large bands beginning in the 1920s. Bandleader-arrangers Fletcher Henderson, Duke ELLINGTON, and, later, Count BASIE, worked out arrangements for their 10- to 12-piece bands, which—unlike traditional jazz bands—were divided into instrumental sections. The rhythm section (piano, guitar, bass, and drums) maintained a steady, even beat; the saxophone and brass sections countered each other with harmonized riffs and repeated figures, with section leaders improvising over this background.

In 1935, Benny GOODMAN's band, using Henderson's arrangements, became the first to achieve mass popularity. Goodman ("The King of Swing") was also the first to integrate his band racially. Whereas the most popular swing bands (those of Jimmy and Tommy DORSEY, Glenn MILLER, Artie Shaw, and Charlie Barnet) were white, some black swing bands also came into prominence—especially Ellington's, Basie's, and those of Earl HINES and Jimmie Lunceford.

Swing's popularity had faded by 1945, brought down in part by a financial conflict between ASCAP (the American Society of Composers, Authors, and Publishers) and the radio networks, and in part by a decline in the popularity of ballroom dancing. Some bands still maintain the style.

Swiss chard see BEET

Swiss Family Robinson, The An adventure novel by J. D. Wyss completed by his son Johann Rudolf Wyss, *The Swiss Family Robinson* (2 vols., 1812–13) has been enjoyed by children around the world without attracting serious critical attention. One of many works inspired by ROBINSON CRUSOE, it is an account of the adventures of a Swiss couple and their four sons who are shipwrecked on a South Sea island. The novel is narrated by the father and has strong didactic overtones, particularly in its religious comments. Modern versions are usually abridged, however, and in this form emphasize the adventure and suspense elements.

switch, electric Mechanical and electronic switches are devices used to interrupt or reestablish the flow of electricity in a circuit. When the switch performs automatically under prescribed conditions, it is called a CIRCUIT BREAKER. A mechanical switch operates by joining and separating electrical contacts at some point in the circuit. A drawback of such a switch is that when it is opened, it induces a spark (arcing), which creates high temperatures that can damage the switch. There are various methods for preventing arcing or, at least, extinguishing the arc rapidly after it occurs.

A mechanical switch may be too slow for some applications, notably in computers. Faster switching is obtained with an electronic switch. The early ones were based on electron tubes, such as the thyratron; more recently, semiconducting switching devices have gained widespread use. Not only are electronic switches faster, they also are free of arcing and mechanical wear.

Swithin, Saint [swith'-uhn] Saint Swithin, d. July 2, 862, was bishop of Winchester and counselor of the Wessex kings Egbert and Æthelwulf. According to a popular English legend, rain that begins on Saint Swithin's day, July 15, will continue for 40 days. Reports of miracles at his original grave led to the transfer of his remains to Winchester Cathedral in 971.

Switzer, Kathy [swit'-sur] Kathrine Switzer, b. Amberg, Germany, Jan. 5, 1947, is a pioneer among women marathon runners. In 1967 she became the second woman to run in the Boston Marathon. Her start was unofficial; women were not permitted in that race until 1972. In 1979, Switzer ceased competing in order to help organize women's racing.

Switzerland Switzerland is a largely mountainous, landlocked country in west central Europe, bordered on the west by France, on the north by Germany, on the east by Austria and Liechtenstein, and on the south by Italy. Its history, culture, economy, and unique character have in large part been determined by the Alpine ranges that cover three-fifths of its total area.

Isolated—and protected—by its relative inaccessibility, Switzerland developed without major hindrance after its founding in 1291 and since 1815 has maintained its independence and present boundaries. Once its Alpine passes were opened by modern engineering, however, Switzerland's position along the principal communication routes between northern and Mediterranean Europe proved a great asset. Its majestic Alpine scenery and carefully tended cultural landscape helped to lay the foundations for a tourist industry whose revenues today are second only to those from manufacturing.

Switzerland is, politically and socially, one of the most stable nations in the world. This stability can be attributed to Switzerland's high standard of living; to the conservative character of its people and institutions; and to the country's noninvolvement in Europe's two major 20th-century wars.

Although Switzerland remains outside the United Nations, the country's participation in world affairs is shown by its membership in the Council of Europe, the European Community (EC), and many agencies of the United Nations. Switzerland is now the permanent base of the UN's Economic and Social Council, the International Labor Organization, and the World Health Organization and, since 1863, the headquarters of the International Red Cross.

Land and Resources

The three clearly defined natural regions of Switzerland are the ALPS, the midland, and the JURA. The Alpine chains stretch from the French border south of Lake Geneva (see GENEVA, LAKE) diagonally across the southern half of Switzerland. The Dufourspitze (4,634 m/15,203 ft) on Monte Rosa is the highest point in Switzerland; next in elevation are the Dom (4,545 m/14,911 ft), the Weisshorn (4,505 m/14,780 ft), and the MATTERHORN (4,478 m/14,692 ft). In this area lie the world-renowned resorts of the Bernese Oberland, Zermatt, and SAINT MORITZ in the INN RIVER valley.

The midland stretches between Lake Geneva and Lake Constance (see CONSTANCE, LAKE). Its hills, plateaus, and valleys are underlain by sandstone, shales, and conglomerates that were deposited by Alpine streams into an inland sea that filled the depression between the Alps and Jura during a period from 65 to 2 million years ago. The region is cut by the tributaries to the RHINE RIVER, which forms most of the northern boundary of Switzerland. Most of the major cities, with the great majority of the Swiss population, are located on the midland rivers and the Rhine.

The mountains of the Jura represent the northernmost fold belt of the Alps. Along the French-Swiss border, and especially in the Jura south of Basel, the mountains take on a plateaulike character. As a whole, the Jura region is sparsely populated. NEUCHÂTEL is the principal city.

The strongly differentiated relief of Switzerland is reflected in the soil pattern. Most midland soils are classified as gray brown podzolics, excellent for the develop-

AT A GLANCE

SWISS CONFEDERATION

Land: Area: 41,293 km^2 (15,943 mi^2). Capital: Bern (1989 est. pop., 135,147). Largest city: Zurich (1989 est. pop., 345,159).

People: Population (1989 est.): 6,619,973. Density: 160 persons per km^2 (415 per.mi^2). Distribution (1989): 60% urban, 40% rural. Official languages: German, French, Italian. Major religions: Roman Catholicism, Protestantism.

Government: Type: federal republic. Legislature: Federal Assembly. Political subdivisions: 20 cantons, 6 half-cantons.

Economy: GNP (1989): $198 billion; $30,270 per capita. Labor distribution (1989): agriculture—6%; manufacturing, mining, and public utilities—25%; construction—10%; transportation and communication—6%; trade—21%; finance—10%; government and services—22%. Foreign trade (1988): imports—$57 billion; exports—$51 billion. Currency: 1 Swiss franc = 100 centimes.

Education and Health: Literacy (1990): 99% of adult population. Universities (1986): 9. Hospital beds (1986): 54,470. Physicians (1988): 18,667. Life expectancy (1990): women—83; men—75. Infant mortality (1990): 5 per 1,000 live births.

ment of forest cover. Less acid are the brown forest soils of the Jura. The soil cover of the Alpine slopes is shallow.

Climate. The wettest parts of Switzerland are the Jura ranges, the central Alps north of the Rhône-Rhine depression, and the Alps of Valais. In the midland, rainfall averages 1,000 mm (40 in) per year, and in winter fog often enshrouds the area. Higher, drier, and colder regions enjoy more sun in winter. Above 3,050 m (10,000 ft) the precipitation falls as snow. In Zurich the average temperature ranges from 0.6° C (33° F) in January to 18° C (64° F) in July.

Flora and Fauna. Forests still occupy about 25% of the countryside. Beech and oak predominate in the deciduous forest of the midland and at lower elevations in Alpine valleys. At higher altitudes spruce and fir take over on moist sites, pine and larch in the drier southern and eastern Alpine interior. Floral elements of Mediterranean origin, among them the chestnut, occupy the southern slopes of the Alps, and they have also established themselves in the Rhône Valley. Palm trees grow along the shores of Lake LUGANO in the Ticino. Above the timberline wildflowers abound in an extensive zone of Alpine meadows.

In a game preserve in the Lower Engadine, several rare Alpine species survive, among them the ibex, chamois, marmot, and eagle. A substantial number of wild animals still roam the midland and Jura forests, especially deer, fox, and rabbit, and, occasionally, the wild boar; the brown bear, emblem of the Bernese canton, however, is now extinct.

Resources. Switzerland is virtually devoid of economically exploitable mineral resources and must rely on imported industrial raw materials and mineral fuels. Waterpower has been the crucial factor in industrialization and still accounts for most of the electrical energy output, although the role of nuclear power has increased in recent years.

People

The ethnic roots of the Swiss people as such can be traced to settlements of CELTS in the northern midland and to an early intra-Alpine population of Illyrian (Dinaric) origin in the upper Rhine and Inn valleys. These groups were later joined by Mediterranean and Germanic peoples.

Language and Religion. In spite of the conventional differentiation into a German, French, and Italian Switzerland, it is mostly language, not ethnic consciousness, that distinguishes different segments of the Swiss population. Today the majority (65%) speak a German dialect known as Schwyzertütsch, while about 18% speak French, 12% speak Italian, and 1% (mainly in the Engadine section of Graubünden canton) speak Romansch, a Romance language belonging to the Rheto-Romanic group. With the exception of a tiny Jewish community, the population is almost evenly divided between Roman

Catholics (49.4%) and Protestants (47.8%).

Demography. The large number of foreigners living in Switzerland (about 15%) strongly affects demographic statistics. Cities with 10,000 or more inhabitants now incorporate 75% of the population. The largest cities—ZURICH, BASEL, GENEVA, BERN, and LAUSANNE—contain a third of the Swiss population.

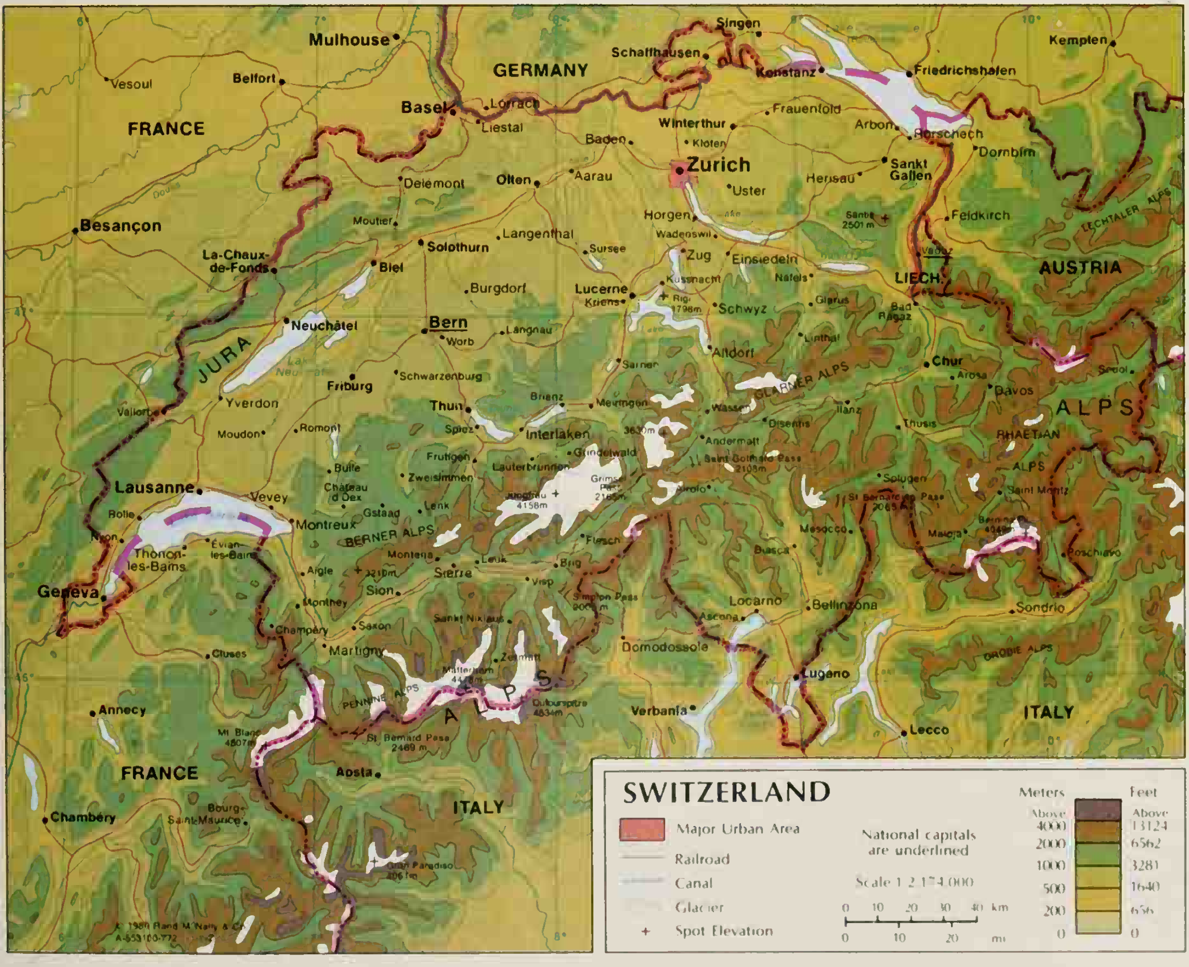
Education and Health. Education is free and compulsory for nine years (in most cantons), but most Swiss children receive at least three additional years of formal education. Two federal institutes of technology (in Zurich and Lausanne) and seven cantonal universities accommodate the portion of the population that goes on to postsecondary education. Switzerland also has many fine private schools that attract students from other countries.

Swiss health standards are among the highest in the world. The Swiss enjoy a life-expectancy rate that is matched in Europe only in Scandinavia and the Netherlands.

The Arts. Folk art reveals itself in many phases of Swiss life, from the characteristic Swiss CHALET to elaborate wood carvings and pottery motifs, religious and secular pageants, and traditional folk music based on the simple melodies of the YODEL and the ALPHORN. Major contributions to international culture have been made by a variety of Swiss individuals: John CALVIN and Ulrich ZWINGLI, two of the greatest leaders of the Protestant Reformation; Jean Jacques ROUSSEAU, the 18th-century political and educational theorist; Johann Heinrich PESTALOZZI, the educational reformer; Carl JUNG and Jean PIAGET, giants in the development of modern psychological theory; writers such as Gottfried KELLER and Jeremias Gotthelf in the 19th century and the novelist Hermann HESSE and the playwright Friedrich DÜRRENMATT in the 20th century; and artists and architects such as Henry FUSELI, Alberto GIACOMETTI, Paul KLEE, and LE CORBUSIER.

Economic Activity

Switzerland is a prime example of a nation overcoming a scarcity of natural resources by basing its economic development on inventiveness, frugality, and perseverance. Switzerland is now one of the most highly industrialized



The peak of the Matterhorn, located on Switzerland's southern border, rises approximately 4,480 m (14,700 ft) above the village of Zermatt. First scaled in 1865, the mountain has brought many climbers and tourists to the alpine resort.

Geneva's lake fountain is a dramatic feature of the city's waterfront on Lake Geneva. The headquarters for many international organizations, Geneva symbolizes the independence and neutrality of the Swiss nation.

countries in the world. Since the 19th century, industrial engineering has made a substantial contribution to the modernization of the Swiss economy, but even in the preindustrial era, the products of Swiss labor were known throughout Europe. Printing and graphics, smithing, machine tooling, watchmaking and clockmaking, carpentry, and masonry were all practiced in medieval Swiss cities. Some of the best-known products of the Swiss food industry, such as Swiss and Gruyère cheese, condensed milk, cocoa, and chocolate, were developed during a century-long effort to process milk into a nonperishable commodity.

Foreigners principally from Italy, constitute a significant portion of the work force. Switzerland's unemployment rate is one of the lowest in Western Europe.

Most of the major industrial complexes are located in the midland. Manufacturing of textiles and clothing is carried on in a large number of factories, many of them in smaller locales. The chemical dye and pharmaceutical industries are concentrated in Basel. The watch industry has its larger plants in Geneva and the Jura.

Agriculture and Forestry. Swiss agriculture is characterized by a highly intensive production on mostly small, owner-operated farms. Two-thirds of the farm population raise cattle, and the value of dairy and beef production (milk, cheese, butter, and meat) amounts to more than half of the agricultural output. More than half the crop farms specialize in bread and feed grains. Where climate permits, agricultural activities include wine production, irrigated fruit and vegetable farming, and apple, pear, and cherry growing.

Transportation. Switzerland's highly efficient transportation network is epitomized by the almost completely electrified, government-owned Swiss Federal Railways. Train travel through the Alps was made possible only by the extraordinary engineering feats represented by the building (1872–1911) of the Saint Gotthard, Arlberg, Simplon, and Lötschberg tunnels. An extensive road system is presently being expanded by the construction of an expressway network that includes several road tunnels through the Alps; the first of these, the Great Saint Bernard, connecting Switzerland and Italy, was completed in 1964; the Saint Gotthard Road Tunnel was opened in 1980. Swiss engineering prowess is also shown by the innumerable cog railways, cable cars, and chair lifts that transport people to well-known resort towns and to the summits of some of the highest Alpine peaks, such as the JUNGFRAU near Interlaken. The Rhine River, navigable to Basel by barge traffic and the Swiss merchant fleet, provides Switzerland's only direct access to the sea.

Trade. Switzerland's foreign trade relies heavily on the interchange of goods with its neighbors in the EC. Its leading exports are capital equipment, watches, and optical instruments, products that account for a large percentage of the value of its exports. The chemical industry (compounds, dyes, and pharmaceuticals) is also important. Imports are evenly distributed among agricultural products, industrial raw materials, machinery, and fuels. A usually negative trade balance is at least partially compensated for by the net income produced by tourism, the insurance industry, and international financial transactions of which Zurich is a world center.

Government and Politics

Switzerland is a federated republic consisting of 20 full and 6 half-cantons. The federal government is divided into three branches: the Federal Council (executive); the Federal Assembly, or Parliament (legislative); and the Federal Tribunal (judicial), which sits in Lausanne. The 7-member Federal Council includes an annually elected president, who serves both as head of government and as chief of state. The president in 1991 was Flavio Cotti. The Parliament has two chambers—the Council of States, whose 46 members serve for 3 to 4 years, and the National Council, whose 200 members are elected every 4 years. Government is usually by a coalition of four political parties—the Social Democratic, the Radical Democratic, and Christian Democratic, and the Swiss People's parties. As the oldest continuous democracy in Europe, Switzerland has traditionally emphasized such legislative mechanisms as the REFERENDUM AND INITIATIVE. Universal suffrage, enjoyed by all citizens over 20, was realized in 1971, when the federal legislature finally granted Swiss women the right to vote.

History

In ancient times, what is now Switzerland was inhabited by the Helvetii, a Celtic tribe, and the Raeti, an Illyrian-Celtic people. After being successively invaded by Julius Caesar's Roman legions in 58 BC, then by the Germanic Alemanni, Burgundians, Ostrogoths, and Franks, the region came under the rule of the HOLY ROMAN EMPIRE in the 10th and 11th centuries. In 1291, however, the cantons of Uri, Schwyz, and Unterwalden declared their independence of the HABSBURGS. They entered into a mutual defense alliance that was later joined by Luzern (Lucerne), Zurich, and Bern. The Austrians, followed by the Burgundians (see BURGUNDY), made a number of unsuccessful attempts to check the momentum of the independence movement over the next 200 years; by the early 16th century, however, Switzerland had not only maintained its independence but was an expanding military power. The Swiss policy of neutrality was embraced after the confederation's defeat by the French at Marignano in 1515.

The REFORMATION and COUNTER-REFORMATION posed a serious threat to the political stability of Switzerland in the 16th century as the country lapsed into civil war. An outside threat during the THIRTY YEARS' WAR, however, served to unite the Swiss people in defense of their interests and led to formal recognition (1648) of the confederation's independence by the Holy Roman Empire. After a century and a half of relative peace, French Revolutionary armies entered (1798) the country from the west and established Switzerland as the Helvetic Republic. At the Congress of Vienna (1815), following Napoleon's defeat, Swiss control was restored and the confederation's neutrality guaranteed by the powers of Europe.

An attempt by several Catholic cantons (the *Sonderbund*) to secede from the confederation was prevented by force in 1847. The 1848 constitution established the 22 (later 20 full and 6 half-) cantons of modern Switzerland, individual civil liberties, a bicameral legislature, and a representative form of democracy. In the following decades, the country's economic base shifted with the advent of mass production: factories were built and urbanization began.

World War I caused political turmoil between the French and German factions of the population, but Swiss neutrality met the test, and in 1920 the League of Nations made its home in Geneva. During World War II, Switzerland mobilized an army of nearly 500,000 to protect its frontiers. Its policy of armed neutrality is today backed up by a national militia force of 625,000; Switzerland has universal conscription for all men between the ages of 20 and 50 years. Since 1945, Switzerland has devoted its energies to maintaining this neutrality, to improving education and welfare programs, and to developing its economy into one of the richest in the world.

sword and knife A sword is a hand weapon having a long blade, sharp on one or both edges, which is held by a grip (hilt). The evolution of the sword coincided with that of the knife, which is a short cutting instrument consisting of one or more blades and mounted on a handle.

Sword

A sword is longer than a dagger, but no fixed rule exists regarding length; for example, the Roman legionnaire's short sword was only 50 cm (20 in) long. Swords can be divided into two basic types according to use: cutting swords, which are heavy and broad and have one or two cutting edges; and thrusting swords, which are slim and pointed and often do not have a cutting edge. These two categories are not restrictive, and many types of swords can accomplish both cutting and thrusting actions. The Neolithic flint dagger probably served as the model for the first swords, which were edged with copper and too soft to be satisfactory. The first reliable swords were two types made during the Bronze Age, about 2000 BC. One was a cutting sword with a leaf-shaped blade, and the other was a longer, narrow-bladed rapier, or thrusting sword. The Assyrians are credited with introducing swords as weapons in warfare. The 6th-century Vikings revolutionized swords and sword making with their discovery of carbonized iron. These double-edged swords were greatly valued and were often presented as gifts of esteem. Probably by chance the Vikings found that if heated iron was folded, beaten, cut, and folded together again, and if the process was repeated, then eventually they could make tough, hard swords that would hold a superior cutting edge. This same manufacturing process also evolved in the Orient, notably Japan, at a much later date. The Arabs also produced the fine Damascus blade, produced by high-temperature forging.

By the 10th century the sword had been lengthened and the tip rounded, thereby becoming a slashing weapon. A cross bar (quillon) was adopted to protect the hands, and most swords were counterbalanced with a round pommel at the hilt's end. The introduction of plate armor in the 14th century brought back tapered thrusting swords, or rapiers, and spurred the development of massive, two-handed cutting swords, or broad swords. In the 16th century the knuckle brow, a metal strap from the pommel to the quillon, was introduced to protect the user's hand; more complicated, basketlike guards were developed by the end of the century. By the 17th century FENCING and dueling came into vogue and required light, easily handled swords known as épées.

Curved swords (scimitars), which were preferred to straight swords in Asia and Eastern Europe, were brought to western Europe by the Turkish invasion in the 16th century. This form was universally adopted as the cavalry saber, an ideal slashing weapon; the saber shape has been dominant since the 18th century. A variation of the saber, the naval cutlass, is a short curved sword with a heavy hand guard and is well suited for the close quarters of boarding operations.

The use of firearms gradually reduced the role of the sword in warfare. Today the sword exists only for fencing and ceremony. Swords of past ages are displayed in museums.

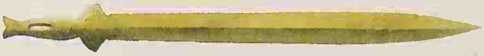
Knife

The knife started as a hand tool made of stone, primarily flint, and later became among the first metal implements. During the period 1500–1100 BC bronze knives served as patterns for swords that appeared in both Crete and Britain.

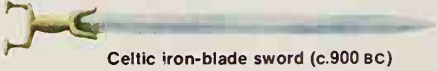
The next important step in the evolution of the knife took place during the first millennium BC, when iron was brought to Europe from Asia. The area of the present-day Austrian province of Styria became the source of the best European iron ore and thus the center for blade production. The cities of Innsbruck and Passau produced exceptional blades through the Middle Ages. Iron knives, heated and beaten to shape, produced a better edge than bronze knives, which were formed by pouring molten metal into stone molds. Iron blades, however, suffered from one weakness: they bent easily. This deficiency was remedied when the Vikings revolutionized the iron industry with the introduction of carbonized iron. Knives were not considered a primary military weapon and retained their domestic role as utilitarian tools through the Middle Ages. Nevertheless, because of the practice of forcing unequipped peasants to serve as troops, common knives were accepted as a standard arm for foot troops.

A knife variation, the dagger, is a pointed stabbing weapon that was popular with both civilians and the military in Europe between the 14th and 16th centuries. The dagger was used when the sword was either lost or broken, in secrecy, or as a coup de grace weapon. German, Italian, and Swiss artisans produced daggers of superb

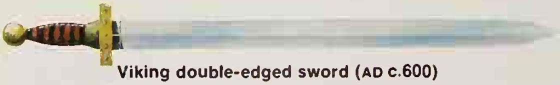
The earliest swords were made by pouring molten bronze into a stone mold. By the 10th century BC, iron swords began to replace their bronze counterparts in Europe. Later refinements included heat tempering and the introduction of the crossbar. Narrow thrusting swords and two-handed broadswords were popular in medieval Europe. The Persian shamshir *and other curved swords of Eastern design influenced the development of the Western cavalry saber.*



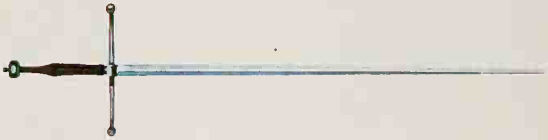
Bronze Age thrusting sword



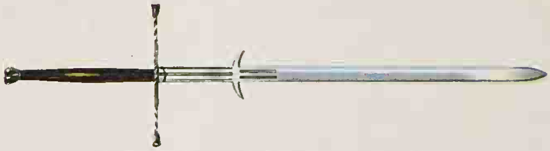
Celtic iron-blade sword (c.900 BC)



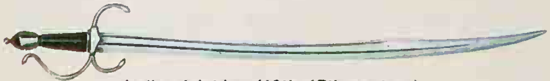
Viking double-edged sword (AD c.600)



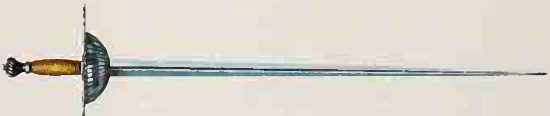
German thrusting sword (16th century)



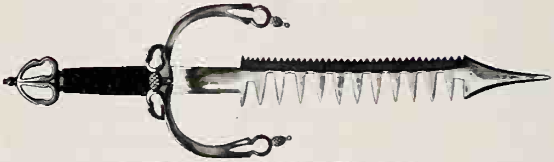
German two-handed sword (16th century)



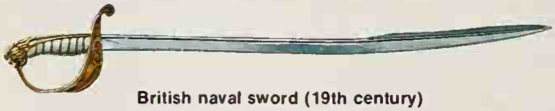
Italian falchion (16th-17th century)



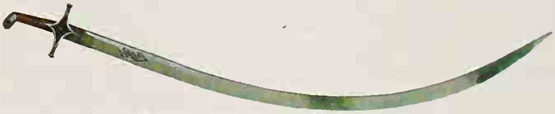
German rapier (17th century)



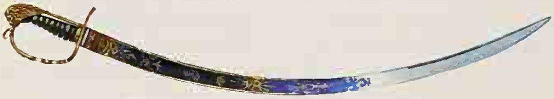
Spanish sword-breaker (17th century)



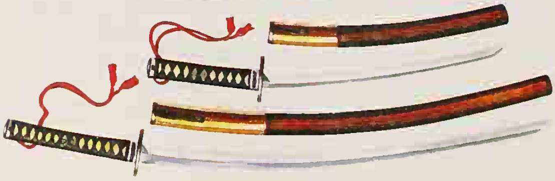
British naval sword (19th century)



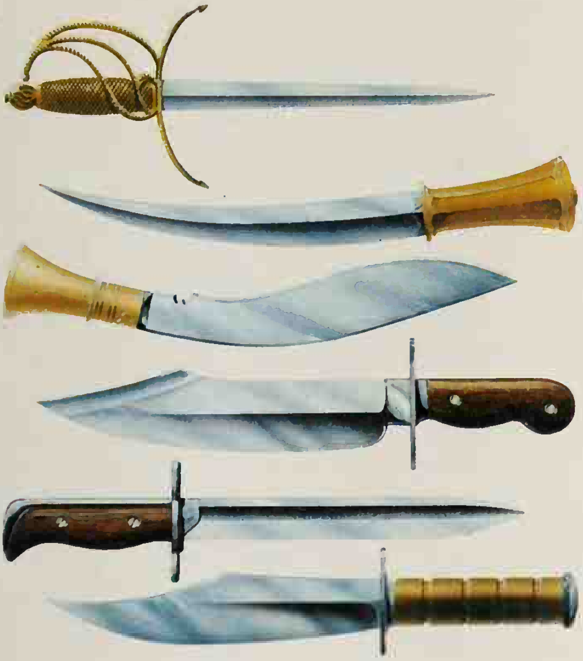
Persian *shamshir* (18th century)



British cavalry sword (19th century)



Japanese samurai swords (18th century)



(Top to bottom) *The dagger, a thin, double-edged stabbing knife, was a favorite weapon in medieval times. The jambiya is a double-edge dagger of Arab design. The Nepalese kukri is a scaled-down version of a 5th-century Greek sword. The Bowie knife, named for American frontiersman James Bowie, was a popular 19th-century hunting and fighting knife. A later version of the Bowie was modified into the K-Bar, an all-purpose commando knife used by the U.S. Marine Corps during World War II.*

beauty during this period. One form, the 14th-century baselard, was probably made originally in Basel, Switzerland; it was reproduced during World War II for ceremonial use in Nazi Germany.

The Arab jambiya, recognized by its curved, double-edged blade, is the most widely used knife in the world, spanning the globe from the African Atlantic coast to the Indonesian islands.

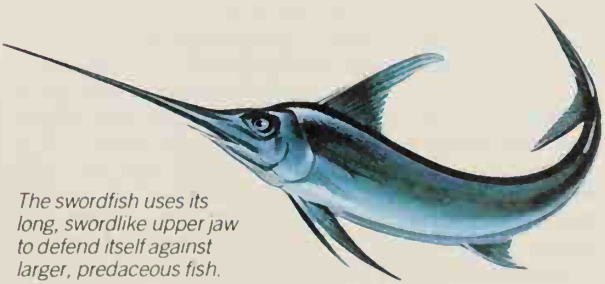
A military application of the knife is the BAYONET. Introduced by the British and French in 1660, the first bayonets were long, pointed knives that could be plugged into the bore of the standard infantry musket. In this manner, the infantry could convert their rifle into a form of pike, which could be used both offensively and defensively. By the end of the 18th century the socket bayonet replaced the plug version; in modified form these remain in service today. A socket bayonet fits around the muzzle of the gun and does not block the barrel, allowing the soldier to fire with the bayonet mounted. Modern bayonets, which are usually knifelike in appearance, are much shorter than their European precursors.

Probably the most famous American knife is the Bowie knife, named for its alleged inventor, Colonel James BOWIE. The Bowie knife is a steel, single-edged knife that measures 38 cm (15 in) in length. Although designed for hunting, it is generally associated with violent fights that frequently took place in American frontier regions.

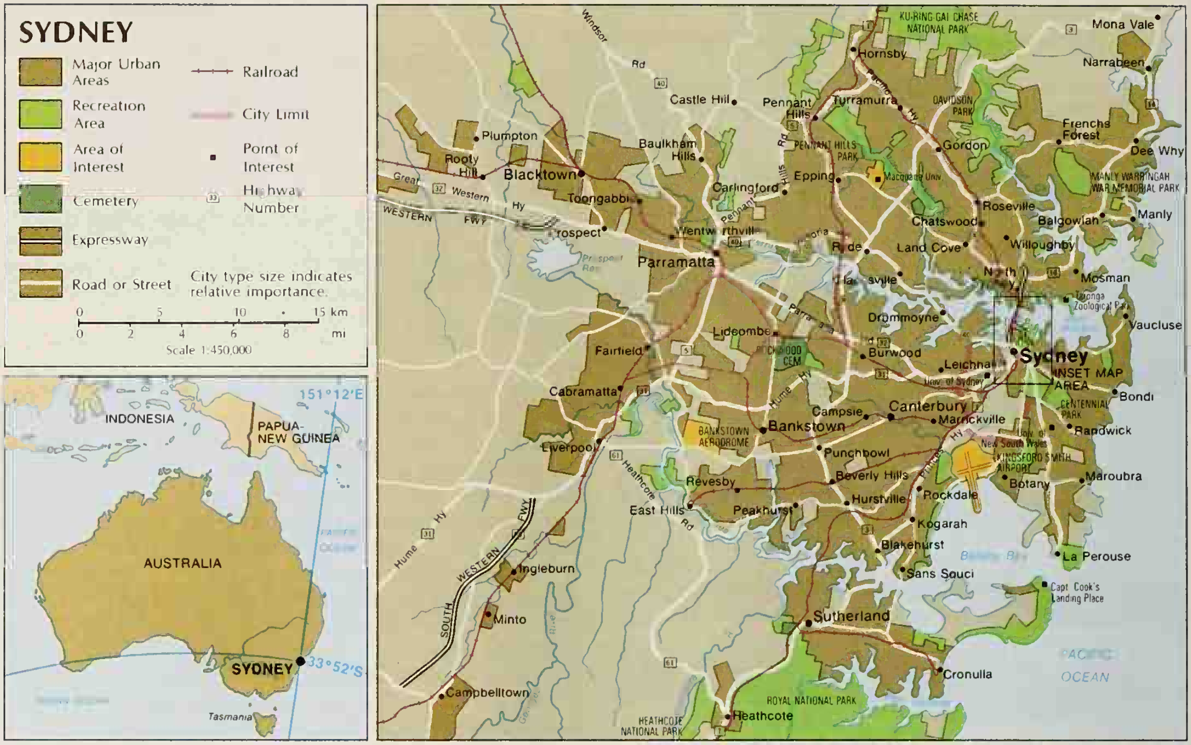
Cutlery, or the family of knives and cutting instruments for domestic purposes, covers a wide spectrum of edged tools ranging from butcher knives to sharpening steels. Modern cutlery manufacturing centers are Solingen, Germany; Sheffield, England; Thiers, France; and the New England states. The invention of stainless steel in 1912 and its introduction into cutlery manufacture revolutionized the industry during the 1920s.

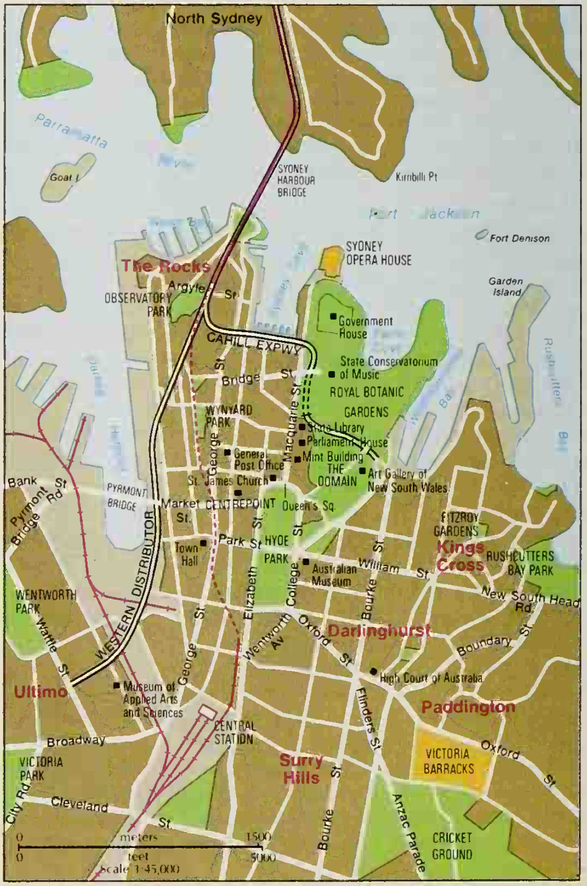
sword dance In many parts of medieval Europe, where the sword was a vital weapon, the sword dance ritualized combat, celebrated the sword as a defense against enemies and evil spirits, and honored man's physical strength, both military and sexual. Performing to fife and drum accompaniment, 6 to 50 men began the dance with a series of rotations, chains, arches, and jumps over and around swords laid on the ground. The center section included exercises of manual dexterity and skill with the swords to demonstrate preparation for battle, and agile feints and dodges among outstretched weapons to simulate the imminent hostilities and inflame the emotions. During the conclusion, the rose—from Middle High German *râz* (braid)—the dancers linked their swords into a tight mesh around which they executed their fiercest fighting tricks. A descendant of the Spartan pyrrhic dance, the sword dance permeated European folklore from the 14th to 18th centuries and survives today in British morris dancing and the deft footwork of the Scottish sword dance. Military tattoos and trooping the colors are diminished modern expressions of aggressive tribal unity.

swordfish The swordfish, or broadbill, *Xiphias gladius,* the sole member of the family Xiphiidae, is found worldwide in tropical and temperate marine waters. The swordlike bill is flattened in cross section. The average length of the swordfish is 1.8 to 3.3 m (6 to 11 ft), of which the bill may be one-third, and the average weight is 45 to 135 kg (100 to 300 lb). Swordfish often bask at the surface, where they become vulnerable to commercial harpooning. They are also caught in tuna traps. Swordfish feed at moderate to great depths, judging from their diet of fishes and squids. They can drive through the wood support of small boats because of their swimming speed—perhaps up to 100 km/h (60 mph).



The swordfish uses its long, swordlike upper jaw to defend itself against larger, predaceous fish.





swordtail Swordtails are live-bearing fishes (family Poeciliidae) in the same genus (*Xiphophorus*) as the platys. They live in the fresh waters of southern Mexico, Belize, and Guatemala. Swordtails are hardy and easily bred aquarium fishes, which also makes them ideal for genetic research. The "sword" is developed in males about one year after birth and sometimes in older females, but not all swordtails have well-developed swords. Swordtails reach 12.5 cm (5 in) in length. They are easily hybridized with platys in an aquarium, producing many color varieties; hybridization in the wild is rare.

Sydenham, Charles Edward Poulett Thomson, Baron [sid'-en-uhm] Charles Poulett Thomson, b. Surrey, England, Sept. 13, 1799, d. Sept. 19, 1841, was a British statesman and governor general of Canada. Sydenham won election to Parliament in 1826. Appointed vice-president of the Board of Trade by the prime minister Earl Grey in 1830, he secured reduction of many customs duties and became president of the board in 1834. In August 1839 he was appointed governor general of Canada. He implemented the plan of his predecessor, Lord DURHAM, to unite Upper and Lower Canada and secured passage of the Canada Union Act in 1841. In 1840 he was created Baron Sydenham of Sydenham and Toronto.

Sydney (Australia) [sid'-nee] Sydney, Australia's oldest community and the capital of New South Wales, is a port city on the southeast coast of the continent. Sydney proper has 86,311 people (1986); greater Sydney, built up around a natural harbor, Port Jackson, has a population of 3,596,000 (1988 est.) and is Australia's most populous metropolitan center. One of the world's longest and highest single-span bridges, Sydney Harbour Bridge, dominates a spectacular harbor view. The Royal Australian Navy is headquartered in Sydney. First settled as a penal colony in 1788, Sydney celebrated its bicentennial in 1988.

Contemporary City. Until the end of World War II, virtually all residents of Sydney were of British ancestry. In recent years, however, many continental European immigrants to Australia have settled in the area. Greater Sydney is administered by 40 separate local governments.

Although Sydney has automobile, textile, and chemical plants and is rapidly becoming the South Pacific's major petroleum-refining city, it remains more an entrepôt than an industrial center. The world's most active primary wool market is located there. In addition to wool and sheepskins, wheat and meat are exported in quantity. A third of Australia's imports come through Sydney, as do most of the country's tourists.

The architecturally distinctive Sydney Opera House, opened in 1973, is the performing-arts center of Sydney. Designed by the Danish architect Jørn Utzon, it sits on a promontory extending into the harbor and resembles a series of immense, wind-filled sails. Landmarks include Saint James Church and Hyde Park Barracks, early-19th-century buildings designed by the convict-architect Francis Greenway. Sydney Tower at Centrepoint (opened 1981) is the tallest building in Australia. The city is home to the Australian Museum, the Art Gallery of New South Wales, the State Conservatorium of Music, and the Museum of Applied Arts and Sciences. The University of Sydney, the University of New South Wales, Macquarie University, and the Mitchell Library are there.

History. Sydney Cove, founded as a penal settlement by Captain Arthur Phillip in 1788 and named for the British home secretary, Viscount Sydney, became the first seat of British authority on the continent. It was not until the 1830s, however, that the city began to thrive, after more free settlers entered the area. The Australian gold rushes of the 1850s accelerated the population surge. Although Sydney was bypassed by Melbourne early in the 20th century as Australia's largest city, it has, since World War II, regained its primacy.

Sydney (Nova Scotia) Sydney (1986 pop., 27,754) is a port city on Cape Breton Island in northeastern Nova Scotia. The city's economy is dominated by the steel industry, which utilizes locally mined coal and iron ore imported from Labrador. Limestone quarrying and fishing are also important. Founded in 1785, the city was the capital of Cape Breton Island until 1820, when the island became part of Nova Scotia.

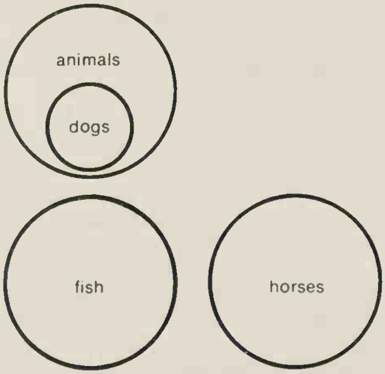
syenite [sy'-uh-nyt] Syenite is a coarse-grained, intrusive Igneous Rock that is composed largely of sodium- or potassium-rich feldspar and of a ferromagnesian mineral. The feldspar commonly is orthoclase, albite, perthite, or, more rarely, microcline, and the dark-colored ferromagnesian mineral usually is biotite mica, hornblende, or a pyroxene; some syenites also contain feldspathoid minerals.

Syenite is in many respects similar to Granite; a major difference is the relative lack (less than 5%) or absence of quartz in syenite. Granite is much more commonly found in nature than syenite.

syllogism [sil'-uh-jizm] The theory of the syllogism, an argument in logic, was first set forth by Aristotle. It has been of basic significance in the development of Western thought. A syllogism consists of three statements; the third is the conclusion, the logical consequence of the two preceding premises. Aristotle's theory actually deals only with the categorical syllogism, in which propositions are in the form of categorical assertions: All *A* is *B*. No *A* is *B*. Some *A* is *B*. Some *A* is not *B*. A typical valid syllogism is:

All elephants are animals.
All animals are living beings.
Therefore, all elephants are living beings.

In Aristotelian logic, it was believed that all reasoning could be put in syllogistic form and then evaluated for its validity. By illustrating a syllogism as a Venn Diagram, one can immediately see if it is valid. The universal statements "All dogs are animals" and "No fish are horses" are shown diagrammatically. It is seen that the domain of dogs is entirely included in that of animals, whereas the domains of fish and horses are mutually exclusive.

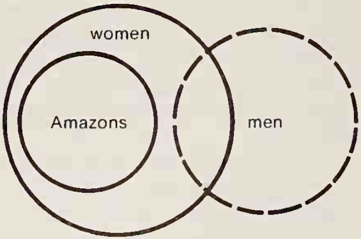


An entire alleged syllogism is:

All Amazons are women.
No men are Amazons.
Therefore no men are women.

This syllogism is seen to be invalid as soon as it is diagrammed (see next page). Solely from the information given, all that can be said is that men might or might not be women, or some men might be women.

From Aristotle until the 19th century the syllogism was the main form of establishing logical validity. During the



20th century Aristotle's view has been shown to be inadequate to express valid arguments in modern mathematics and has been replaced by the propositional calculus.

sylph [silf]. In the theories of the 16th-century alchemist PARACELSUS, a sylph is an elemental being without a soul that inhabits the air and influences humans' bilious temperament. Sylphs are traditionally associated with chastity.

symbiosis [sim-bee-oh'-sis] Symbiosis (*sym*, "together"; *bios*, "life") refers to various kinds of close and permanent associations between members of different species. Mutualism is the relationship wherein both members benefit and cannot exist without each other; for instance, lichen is a mutual partnership between a fungus and an alga. When one partner is benefited and the other is relatively unaffected, the relationship is called commensalism, for instance, the epiphytic orchids that grow on tree branches in the tropics. Parasitism refers to a relationship in which one organism benefits and the other is harmed, for instance, tapeworms in the gut of animals.

symbolic logic see LOGIC

symbolism (art) The term *symbolism* has both a general and a specific meaning in art history. In its broadest sense the term means the use in a work of art of a sign or object to stand for something other than itself. A symbol's effectiveness depends on the presumption that its meaning can be understood by its audience. In art the terms ICONOGRAPHY and *iconology* are frequently used to refer to the study of the meaning and interpretation of symbols and allegories.

In its specific use, the term *symbolism* refers to an artistic attitude that became dominant in both the visual arts and in literature during the latter decades of the 19th century. Inspired by the spirit of early-19th-century romanticism, the symbolist movement originated in France during the 1880s and rapidly became international in scope. The symbolists sought images that probed the emotional and irrational aspects of human existence in opposition to the prevailing neoclassical, academic, and realist modes of representation. In France, Pierre PUVIS DE CHAVANNES, Odilon REDON, and Gustave MOREAU initiated the symbolist movement in painting. Their ideas formed the basis for the achievements of the postimpressionists Paul CÉZANNE, Paul GAUGUIN, Georges SEURAT, and Vincent VAN GOGH. By the turn of the century, symbolism had become an international phenomenon in the work of such artists as James ENSOR (Belgium), Edvard MUNCH (Norway), Ferdinand HODLER (Switzerland), Gustav KLIMT (Austria), Aubrey BEARDSLEY (Great Britain), and Jan Toorop (the Netherlands). The symbolists used arcane subjects, exaggerated shapes, and vivid colors to produce emotive imagery. Their ideas became fundamental to much of 20th-century art, influencing Pablo Picasso, Henri Matisse and the Fauves, and Wassily Kandinsky and the German expressionists. Other modernist movements incorporating symbolist attitudes include the NABIS, ART NOUVEAU, and later, SURREALISM.

Paul Gauguin created Vision after the Sermon, *or* Jacob Wrestling with the Angel *(1888; detail), after a visit to Brittany. Gauguin organized (1889) the first symbolist exhibition, entitled "The Impressionist and Synthetist Group." (National Gallery of Scotland, Edinburgh.)*

symbolism (literature) The symbolist movement in literature was at first primarily a French development continuing those changes effected in French poetry by romantic writers and the Parnassians. It drew inspiration from England, Germany, and the United States (above all from Wagner and Poe), and its most important French precursor was Charles BAUDELAIRE. The major French writers most often identified as symbolists are Stéphane MALLARMÉ, Arthur RIMBAUD, and Paul VERLAINE in the 19th century and Paul CLAUDEL and Paul VALÉRY in the 20th. Other important French writers associated with symbolism are Tristan Corbière, Jules LAFORGUE, le comte de Lautréamont, and Guillaume APOLLINAIRE. The name *symbolist* was established for the movement by the manifesto of Jean Moréas in the Paris newspaper *Le Figaro* of Sept. 18, 1886.

In poetry, the symbolists opposed didacticism, eloquence, political reference, sentimentality, and objective description. Their poems present subtle personal moods or hallucinative play of the senses or they evoke sensuous reverie or ideas through complex and at times hermetic imagery. Baudelaire sees language and writing as "magical operations, evocative sorcery," stresses their "hieroglyphic" quality, and states that even ordinary sights can be symbols revealing "the profundity of life." Verlaine calls for nuance rather than color and above all else for music. Rimbaud refers to "the alchemy of the verb" and urges poets to make themselves seers, and Mallarmé insists that the writer should merely suggest, not name, an object—to include on paper not the "intrinsic wood" of the trees in a forest, but only "the silent thunder" adrift in its leaves.

French symbolist writings and ideas soon reached the British Isles, the rest of western Europe, Russia, and the Americas, influencing numerous 20th-century poets such as William Butler Yeats, Rainer Maria Rilke, T. S. Eliot, and Wallace Stevens.

symmetry (mathematics) In mathematics, *symmetry* denotes a balance of the parts of a figure relative to a central point, line, or plane. For example, two points *P* and *Q* are symmetric with a third point *M* if *M* is the midpoint of line segment *PQ*. A figure is symmetric if, for each point *P* of the figure, there is a corresponding symmetric point *Q* of the figure. Axial symmetry is a case in which a figure can be divided by a line into mirror-image halves. Another common case is radial symmetry, in which a figure can be made to coincide with itself if it is rotated about a point. Central symmetry is a special case of radial symmetry corresponding to a rotation of 180°.

symmetry (physics) A physical system is said to exhibit a symmetry if it remains unchanged under a given operation. For example, a ball looks the same under rotation in any direction about its center; the ball is said to have a spherical symmetry. Symmetries play a fundamental role in the understanding of various physical phenomena. They are an especially important part in the study of elementary-particle physics (see ANTIMATTER), where the exact nature of the force laws is still unknown. The significance of symmetry is that many important aspects of the behavior of a system may be predicted on the basis of its symmetry without a detailed knowledge of its inner workings.

All symmetries may be classified into two types, discrete and continuous. For a discrete symmetry, there are only a finite number of operations that can lead to identical physical configurations: for example, a square drawn on a paper has a discrete symmetry because there are only four ways it can be rotated about an axis perpendicular to the plane of the paper to look unchanged. On the other hand, a circle drawn on a piece of paper looks unchanged after rotation through any angle about an axis perpendicular to the paper. Thus the circle exhibits a continuous rotational symmetry.

Some other examples of continuous symmetries are space-time translations and rotations. The former refers to all points in space and time being equivalent as far as physical laws are concerned, and the latter refers to the equivalence of all directions in space (isotropy of space). Two important examples of discrete symmetry are space reflection and TIME-REVERSAL INVARIANCE. Many physical laws are unchanged under mirror reflection (see PARITY, PHYSICS) and under the reversal of the direction of time.

Symmetries and Conservation Laws. A conservation law states that some physical parameters of a system remain unchanged during the time evolution of the system (see CONSERVATION, LAWS OF). For example, in classical (nonrelativistic) physics, the total mass of a system is fixed before and after, for example, a collision process (the conservation law for mass). Similarly, the total linear and angular momentum and the total energy of a system obey conservation laws in both relativistic and nonrelativistic physics. Since the advent of the Lagrangian formulation of physics, it has been established that existence of conservation laws is related to the existence of underlying symmetries. For example, the conservation of linear momentum is a direct consequence of invariance of the Lagrangian under space translation, or homogeneity of space. Similarly, conservation of energy follows from invariance under time translation. The conservation of angular momentum is a result of rotational invariance. Symmetry under space reflection leads to parity invariance.

In order to discover the nature of the conservation laws operating in a system, the nature of the forces in the system and the associated symmetries must be studied. Because all forces derive their origins from the potential energy, it is enough to study the potential energy to discover conservation laws. For example, the Earth and the Sun attract each other through a force that depends only on the distance between the two and not on their orientation (a central force). The force law is rotationally invariant and thus leads to conservation of angular momentum. Because the direction of angular momentum is perpendicular to the plane of rotation, the Earth and Sun are locked in the same plane forever. Thus any two bodies interacting through a central force will have this property.

Selection Rules. Symmetries allow only certain final states once the initial state is given, implying, in turn, that appearance of many final states is forbidden, or at least highly improbable. The rules governing such transitions are called selection rules and are important in the study of atomic systems, where knowledge of allowed initial and final states determine, for example, the intensity and energy of the emitted light of lasers.

Internal Symmetries. The symmetries discussed so far involve space or time, or both. Certain symmetries, though, are known to exist where the symmetry operation changes one type of particle into another. For example, it is known that in the nucleus the same force exists between a proton-proton, proton-neutron, and neutron-neutron pair, meaning that there is a substitution symmetry between the proton and the neutron. In an imaginary "space," where the proton and the neutron form two hypothetical directions, any rotation in that space will leave the nuclear forces unchanged. This feature is called isospin symmetry. The inclusion of additional particles in such a space leads to the higher unitary symmetries. Other examples of internal symmetry are electric charge and baryon number, which also owe their origin to operations in a fictitious internal space.

The internal symmetries may operate the same way or be different at each space-time point. In the latter case they are called gauge symmetries. In the 1960s theorists applied gauge symmetry to the concepts of both the weak and electromagnetic forces. They considered the idea of "spontaneous symmetry breaking," in which certain relations in theory can have exact symmetry, yet in their physical manifestations do not provide neat representations of the symmetry. The result was a single mathematical model that incorporated both forces: the electroweak theory. Successful predictions of the electroweak theory proved its validity (see FUNDAMENTAL INTERACTIONS). Theorists now employ symmetry theory in attempts to combine the electroweak force with the strong nuclear force in what are called grand unification theories. They also attempt to reconcile all four forces, including gravitation, in so-called supersymmetry or supergravity theories (see UNIFIED FIELD THEORY). Theorists in the field of cosmology (see COSMOLOGY, astronomy) use symmetry principles in inflationary models (see INFLATIONARY THEORY) that attempt to elucidate the finer aspects of the BIG BANG THEORY, explaining cosmic evolution.

Symons, Arthur [sim'-unz] The English poet and critic Arthur William Symons, b. Feb. 28, 1865, d. Jan. 22, 1945, is best known for his critical work *The Symbolist Movement in Literature* (1899), which helped popularize in England the work of the French symbolist poets. Influential in late-19th-century literary circles, Symons edited the *Savoy* magazine from 1896. His own volumes of poetry include *Silhouettes* (1892) and *London Nights* (1895).

symphonic poem *Symphonic poem* is a term invented by Franz Liszt to describe the series of orchestral works that he wrote between 1850 and 1860, all of which derive their musical form and rhetoric from nonabstract ideas, some of them poetic and some visual. That Liszt did not insist on a strictly literary source for each work is important, because composers who followed his lead enjoyed greater variety of form and title (tone poem, fantasia, study, sketches) while nevertheless cleaving to his model of thematic transformation and development. Topics stemming from nationalistic sources proved especially popular.

symphony As developed since the latter half of the 18th century, the symphony is a SONATA for orchestra normally in four movements or self-contained parts (exceptions include works in only one part and as many as six parts).

The term *symphony* is derived from the Latin *symphonia*, meaning literally "a sounding together." In the late 16th and early 17th centuries it meant an instrumental section—often the beginning or ending—of an otherwise vocal piece.

By the first half of the 18th century, however, *sinfonia* was practically synonymous with the three-movement OVERTURE, the standard beginning of an Italian opera or oratorio. These *sinfonie* were sometimes presented separately as concert pieces, by Giovanni Battista SAMMARTINI and others. In northern Europe, particularly Austria and Germany, by 1740 the symphony became a four-movement concert piece with the addition of a minuet generally as the third movement. Johann Stamitz (see STAMITZ family) excelled in the form with his famous orchestra at the court of Mannheim.

Franz Josef HAYDN solidified and enriched the symphonic style between 1757 and 1795; his 107 symphonies were widely performed and imitated during his lifetime. Wolfgang Amadeus MOZART's last six symphonies are of complex architecture and rich orchestration, and they remain unsurpassed for their marriage of formal perfection and expressive depth.

Ludwig van BEETHOVEN greatly increased the form's weight and size. With his Third Symphony ("Eroica," 1805), he created a gigantic and complicated structure exceeding even the most sophisticated works of Haydn and Mozart, and he expanded the form further in his Ninth Symphony (1824), with vocal soloists and chorus.

Although influenced by Beethoven, Franz SCHUBERT's technique, even in the "Great" C Major Symphony (1828), was in many respects much more fragmented. The *Symphonie fantastique* (1830) of Hector BERLIOZ, with its introduction of the *idée fixe* (motto theme) and its nightmarish atmosphere, was a great innovation.

Felix MENDELSSOHN followed classical tradition in most of his symphonies. Robert SCHUMANN composed four beautiful symphonies (1841–51) that present problems in orchestration. Franz LISZT wrote many symphonic poems and a *Faust Symphony* (final version 1857). The most popular symphonies of the late romantic period are those of Johannes BRAHMS, classically rigorous in style, and the brilliant, dramatic works of Peter Ilich TCHAIKOVSKY. Anton BRUCKNER's huge, powerful symphonies (1863–96) are considered by many the culmination of the romantic orchestral style. As Europe became more intensely national, the symphony tended to be associated with the new nationalist schools. The Austrian Gustav MAHLER wrote ten symphonies (1888–1911; tenth unfinished) whose tortured style may be considered a summing-up of the trend since Beethoven.

In the 20th century the symphony has continued to dominate the musical thought of many composers, among them the Finn Jean SIBELIUS, the Dane Carl NIELSEN, the Russians Sergei PROKOFIEV and Dmitry SHOSTAKOVICH, and the Englishmen Sir Edward ELGAR and Ralph VAUGHAN WILLIAMS.

synagogue The synagogue (from the Greek word for "assembly"), a building where Jews gather for worship and religious instruction, is the focus of Jewish life in every community. Ancient temples, including the Temple in Jerusalem, were regarded as dwelling places of the deity; in them sacrificial rites were performed by a special caste of priests. The synagogue, in contrast, is a gathering place for the people. Its services consist of prayer, song, and instruction. The custom of regular preaching originated in the synagogue. Any member of the congregation with the requisite scriptural knowledge may lead the prayers and preach.

Synagogue buildings existed in Egypt and Palestine in the last three centuries BC. Long before the destruction of the Temple (AD 70), the synagogues of Palestine and the Diaspora were the functioning centers of Judaism and were used by the PHARISEES and their successors, the RABBIS, to create a unified and informed Jewish community.

Today synagogues usually include classrooms, recreational facilities, and offices. The hall of worship has seating for the congregation, a pulpit called *bimah* (from the Greek) or *almemar* (from the Arabic) with a desk for the reading of the Torah scrolls, and an ark in which the scrolls are kept.

synapse see NERVOUS SYSTEM

synchrotron see ACCELERATOR, PARTICLE

synchrotron radiation Synchrotron radiation is electromagnetic radiation that is produced by the acceleration of high-energy charged particles in a magnetic field. It is so named because of its role as an energy-loss mechanism in early synchrotrons in the 1950s (see ACCELERATOR, PARTICLE), but it was first observed in 1946 in an electron accelerator and had been known in theory since the 1910s. It is of great importance in RADIO ASTRONOMY as the primary source of intense radiation in the radio region of the electromagnetic spectrum. Since the 1960s it has also become increasingly important as a means of conducting spectroscopic studies at wavelengths ranging from about 1,000 to 0.1 angstroms, or 100 to 0.01 nanometers (1 nanometer equals 10^{-9} m). Synchrotron radiation is now a research tool in solid-state physics, chemistry, Earth science, biology, medicine, and industry. Specialized facilities have been established as radiation sources, in addition to the numerous high-energy accelerator laboratories already in existence.

syncline and anticline Synclines and anticlines are FOLDS in layers of sedimentary rock. A syncline is a downfold, in which the youngest rocks occupy the trough of the structure. An anticline is an upfold, in which the youngest rocks occupy the crest. In advanced stages of erosion, anticlines and synclines develop into series of parallel ridges and valleys, with ridges forming on the layers of harder rock and valleys on the softer layers. Plunging folds descend at an angle into the Earth's crust; their erosion results in a zigzag pattern of ridges and valleys.

SYNCOM [sin'-kahm] SYNCOM (from *syn*chronous *com*munications satellite) was a series of three satellites that demonstrated the feasibility of communications by a satellite in a synchronous orbit (which would make it appear to be stationary over one point on Earth; see COMMUNICATIONS SATELLITE). It was a joint developmental project of NASA and the U.S. Department of Defense.

SYNCOM 1 was launched from Cape Canaveral by a Thor Agena rocket on Feb. 14, 1963. Even though it achieved the desired synchronous orbit, communications were lost, and it never became functional. *SYNCOM 2*, launched on July 26, 1963, went into the desired orbit at a position over the east coast of Brazil. Many voice and teletype messages were sent between it and the tracking ship U.S.S. *Kingsport*. Additionally, even though the satellite was not designed to do so, successful tests were made to see if it could relay television signals. Also, precise determinations of variations in its orbit permitted a much more accurate estimate of the true shape of Earth.

SYNCOM 3, launched on Aug. 19, 1964, took a permanent position over the equator between the United States and Japan. From there it transmitted pictures of the 1964 Olympics in Tokyo, sometimes using *Relay 2* to make them available in Europe.

syncopation Syncopation (from *syncope*, "the skipping of a heartbeat") is the temporary disruption of the normal pattern of accent in a musical composition. To be audible as such, syncopation must depart from an established regular rhythm, which continues to shape the listener's expectations. The feeling of syncopation may be produced by accentuating what are ordinarily the weak beats of a measure, by deemphasizing the strong beats, or by these procedures in combination. While present in almost all music, syncopation is especially prevalent in the work of Western composers of the late 14th century and also in much African music and the jazz derived from it.

syndicalism Syndicalism is a socialist political doctrine calling for control of the economy by organized labor and the abolition of the state. Developed in 19th-century France, syndicalism (the term derives from *syndicat*, French for "trade union") reached its peak in France early in the 20th century. Louis Auguste BLANQUI, Pierre Joseph PROUDHON, and especially Georges SOREL were the important theorists of the movement. Sorel asserted that violent revolution by trade unionists was the only means by which socialism could triumph. According to him, BOYCOTTS, GENERAL STRIKES, and SABOTAGE were the major weapons to be used to achieve the goal of a workers' commonwealth.

Syndicalism spread to workers' movements in Italy, in Spain and Latin America, and in the United States, where it influenced the INDUSTRIAL WORKERS OF THE WORLD

(IWW). For the most part, syndicalism declined as a political movement after World War I, although it continued to be a force in Spain and Latin America through the late 1930s.

synecdoche see FIGURES OF SPEECH

synergism [sin'-ur-jizm] Synergism, or synergistic effect, refers to the action of two different chemical substances acting together to create a greater effect than the sum of the actions produced by each acting independently. This effect is of importance in catalytic reactions, in the use of insecticides, in the application of certain drugs, and in extraction processes in industrial chemistry. It is believed that this effect occurs either because the two chemical substances react together in some manner or because intermediate products form that react with each other to create the increased effect.

synesthesia [sin-es-thee'-zhuh] Synesthesia is experiencing with one sense a stimulus appropriate to another, as in "seeing" sound or "tasting" colors. Synesthesia is generally associated with drug-induced "highs" but also occurs to some people naturally. True synesthesia is a strong and often disconcerting experience, as, for instance, when a color produced via synesthesia from a sound interferes with the perception of real colors.

Synge, John Millington [sing] The greatest playwright of the modern Irish theater, J. M. Synge was born near Dublin of an Anglo-Irish Protestant family on Apr. 16, 1871, and died Mar. 24, 1909, too early to witness the widespread acceptance his plays would win in Ireland and throughout the English-speaking world. After attending Trinity College, Dublin, Synge lived in Germany and then in Paris, where he met William Butler Yeats, who encouraged him to visit the Aran Islands and to write about the Irish peasant.

In 1903 the Irish National Theatre Society performed Synge's one-act comedy *In the Shadow of the Glen*, but it was considered morbid and un-Irish. In 1904 his *Riders to the Sea*, one of the most moving short plays in modern drama, received a more favorable reception. The three-act *The Well of the Saints*, however, performed in 1905 in the newly opened ABBEY THEATRE, increased the critics' suspicions of Synge's motives, whereas *The Playboy of the Western World* (1907) seemed such a malignant travesty of the national character that Abbey audiences disrupted the play's performances for several nights. A grotesque extravaganza about peasant life, written in a highly rhythmic prose of rich comic excellence and lyric beauty, *The Playboy* eventually gained recognition as a classic. Of his six plays, only *The Tinker's Wedding* (1908) was thought too inflammatory to produce.

Synge spent his last months unsuccessfully trying to finish his beautiful *Deirdre of the Sorrows*, a retelling of an old Irish love story. After his death the play was assembled from his drafts and notes by his friend Yeats and his fiancée, Maire O'Neill, who played the title role at its first performance in 1910.

syntax Syntax, the study of sentence structure, is to be distinguished from such other branches of LINGUISTICS as LEXICOLOGY AND LEXICOGRAPHY; SEMANTICS; and PHONOLOGY AND MORPHOLOGY.

Central to syntactic analysis is the observation that some sentences are considered syntactically ill-formed, or ungrammatical, because of improper word order, because of the improper form of component words, or for other reasons. A grammatical sentence, one that in syntactic terms is properly constructed, may nevertheless be incoherent in sense, such as *The brick munched on pink sadness*—or it may be so awkwardly structured as to be difficult or impossible to use. Speakers of a language have the ability to construct and understand an infinite number of distinct sentences, because from a grammatical sentence of any length, a still longer one may be formed. The central problem of syntax is to explain how a finite body of knowledge lets speakers handle an unbounded set of sentences.

Syntactic Rules. Sentences are formed by combining smaller units, such as words, to make larger units. This combination usually follows regular patterns, the so-called syntactic principles or rules. The rules may be understood as part of the psychological organization of speakers, but the term is also used for statements made by grammarians or linguists in an attempt to describe the patterns.

The syntactic rules of a language must permit the construction of an infinite number of grammatical sentences while excluding the infinite number of strings of elements considered ungrammatical. For instance, a syntactic rule of English permits one clause to be used as the direct object within another clause (*I know* is the direct object in *He knows I know*, for example); a complex clause so derived may in turn be used as the direct object in a still larger expression (as in *I know he knows I know*), and so on indefinitely.

Morphemes. In syntactic structure, the smallest units that must be posited are morphemes—the smallest identifiable units with constant meaning or grammatical function. The word *dogs*, for instance, may be broken down into the morphemes *dog* and *s;* and *unfavorable* into *un, favor*, and *able*.

Usually one of the morphemes in a polymorphemic word may be regarded as the root to which other morphemes are added as prefixes or suffixes to form larger units. *Dog* and *favor* are the roots in the words cited above; prefixes and suffixes adhere to them in layers that constitute the morphological structure of the complex words. As a general tendency, affixes—prefixes or suffixes—in the outer layers of the morphological structure pertain to grammatical function or relations, such as the *-ly* of *independently*, which marks the word as an adverb. The derivation of complex lexical forms from simpler ones often follows regular rules or patterns of varying generality. Adverbs, for example, are often formed by adding *-ly* to an adjective.

Besides words and morphemes, sentences are organized into larger units—in particular phrases and clauses. The units are hierarchically arranged: a sentence may be broken down into one or more clauses, a clause into one or more phrases, a phrase into one or more words, and a word into one or more morphemes.

Parts of Speech. At the level of words and morphemes, the most familiar classification is that represented by the traditional PARTS OF SPEECH. A root or larger unit that belongs to one class may be shifted to another by adding a prefix or suffix, as when the verb *favor* becomes an adjective by the suffixation of *-able,* or when the suffix *-ly* derives an adverb from the adjective *independent.* An affix may also leave the class membership unchanged (*dog* and *dogs,* for example, are both nouns; *favorable* and *unfavorable* are both adjectives), or class membership may be changed without the addition of an affix (for example, *bark* may be either a verb or a noun).

Besides the basic division into parts of speech, linguists recognize a need for a much finer classification of words and morphemes. Any grammatical property with respect to which the members of a class differ provides the basis for a subclassification. For example, the class of adjectives in English may be subdivided into those which take the prefix *un-* (such as *favorable, healthy, true,* and *happy*) and those which do not (such as *sad, false, good,* and *orange*). Similarly, English verbs that take direct objects may be divided into a large subclass of verbs that participate in the type of sentence called the passive and a small subclass that do not (the verb *have,* for instance: the passive of *She has a nice smile*—namely, *A nice smile is had by her*—is ungrammatical).

Phrases and Clauses. A phrase is a sequence of words, centered on a core element called the head, that constitutes a coherent grammatical unit of the same basic type as the head. For example, *a good writer* is a noun phrase centered on the head noun *writer. Works hard* and *may have been eating peanuts* are called verb phrases; *under the workbench* is a prepositional phrase; and so on.

A clause is a larger unit, one that resembles a simple sentence in its parts and their arrangement. In traditional terms the major units in a clause are a subject and a predicate. The subject is some type of noun or noun phrase, but the predicate may have as its central unit a verb, an adjective, a noun phrase, a prepositional phrase, or an adverb. From a more modern perspective and focusing just on clauses with verbs as the central predicate element, a clause may be viewed as specifying a relation among various participants, each identified by a noun phrase and playing a certain role in the clause.

Languages use several kinds of devices for distinguishing the subject and object: word order, as in English, where the subject usually precedes the verb and the object follows it; case inflection, such as *he* for subject and *him* for object; the attachment of a wordlike case-marking particle; verb agreement, as in *I am* versus *he is*; or any combination of these.

A sentence with only one clause is said to be simple; a sentence with more than one clause is complex. The clauses of a complex sentence may be juxtaposed, with neither contained inside the other, in which event they are said to be conjoined or coordinate. When one clause is contained inside another, it is said to be a subordinate clause, and the clause in which it functions is called the main clause.

Generative-Transformational Grammar. Since the publication in 1957 of Noam CHOMSKY's book *Syntactic Structures,* linguistic studies of syntax have been dominated by the theory of generative-transformational grammar. The central tenet of the theory is that in addition to the overt grammatical form of sentences, called surface structure, there is also an underlying level of grammatical organization, called deep structure. Whereas the deep structure of a sentence may differ radically from its surface form, the relation between the two levels is a function of general syntactic rules called transformations, which are thought to derive surface structures from their underlying, semantically oriented representations. Additional, semantic rules relate deep structures to appropriate semantic representations (representations of meaning), and phonological rules relate surface structures to phonetic representations (pronunciations).

In some instances, two sentences are so similar in meaning and syntactic organization that despite their surface differences, they are most plausibly viewed as manifestations of the same deep, semantically oriented structure. Other instances reveal an antithetical situation in which two sentences differ radically in meaning—and hence may be presumed to have different deep structures—despite similarity or identity of surface form. Deep structures therefore represent in a direct and consistent way the participants in a sentence and their semantic roles, which are often reflected only indirectly at the surface level.

synthetic fibers Synthetic fibers are fibers made from chemicals rather than from such natural sources as animal hair or plant filaments (see FIBER, NATURAL). Fiber producers can control the size, shape, surface, and other physical aspects of their synthetics. Fibers used primarily for textiles are usually heat-, moisture-, and mildew-resistant, stretchable, and easy to dye. Synthetic fibers made for other purposes are often superior in strength and durability to the metals and other materials they can replace. Nearly all synthetics are made from PETROCHEMICALS; many resemble PLASTICS in their chemical structures.

History. In 1884 the Frenchman Hilaire de Chardonnet invented a process for treating natural cellulose such as wood pulp with solvents, and spinning the resultant liquid into fiber (see RAYON). NYLON, made (1938) by the DuPont Company, was the first commercially successful fiber wholly synthesized from chemicals. Wallace H. CAROTHERS formulated the theory of long-chain polymerization, providing the scientific foundation for synthetic fiber production.

The process for making all oil-based synthetic fibers is basically the same. Certain organic chemicals, products of oil refining, are combined into a syrupy substance and forced through the tiny holes of a spinneret. Cooled and solidified, the resultant filaments are stretched to produce the degree of strength and elasticity desired, then crimped, coiled, or otherwise textured before being woven or knitted into fabric. The fibers can be blended with others, or—in the case of high-performance fibers—melted down with metals or ceramics to produce composite materials.

Textile Fibers. Synthetic textile fibers can be designed to meet specific performance or appearance requirements. Nylon, for instance, is strong, durable, and lightweight; it can be produced as an extremely fine thread, for women's hosiery; as a thicker, glossy thread, for lingerie; and as a thick fiber for reinforcing vehicle tires. Orlon and other woolly acrylic fibers are used for sweaters and furlike fabrics. Elastomeric synthetics have largely replaced rubber in stretchable textiles. Hollow polyester fibers make lightweight clothing insulation. Polyester "microfibers" produce water- and wind-resistant fabrics that are also vapor permeable—that is, they allow perspiration vapors to pass through.

High-Performance Fibers. High-performance fibers are distinguished by their extremely high temperature resistance and extraordinary strength. Aramid fibers, for example, are similar to nylon, but their slightly different chemical structure makes them stronger than steel. Kevlar, a fiber made from aramid, is used to make bulletproof fabrics and clothing that is resistant both to heat and to chemicals. Aramid fibers, along with many other high-performance synthetics—carbon, boron, silicon, and aluminum-oxide fibers—are used to produce lightweight, superstrong composite structural materials.

Fibers made from glass are used as insulation, to form composite structural materials when mixed with certain plastics (see FIBERGLASS), and as the light-carrying structures in FIBER OPTICS.

synthetic fuels Synthetic fuels are gaseous and liquid FUELS produced by the conversion of other, less-desirable, organic materials. They can be derived by various means from oil shale, tar sands, coal, and renewable biomass sources.

Two techniques are used for conversion of coal to liquid fuels. One is the "indirect" liquefaction process, already in industrial use, in which coal is converted to a synthesis gas (a mixture of hydrogen and carbon monoxide) and passed over a catalyst to produce such liquid fuels as GASOLINE, diesel fuel, and methanol. In the "direct" liquefication process hydrogen is added to coal (HYDROGENATION) at high temperature and pressure, converting it to a liquid that can be refined into conventional fuels. Coal may also be converted to combustible gases, including synthetic NATURAL GAS, hydrogen, and synthesis gas.

Liquid fuels are also produced from oil shale (see SHALE, OIL) and TAR SANDS. Oil shale is usually heated (see PYROLYSIS) to produce a heavy oil, whereas tar sands are treated with hot or cold water solvents to recover the oil clinging to the sand granules. Biomass materials—wood, grain and sugar crops and their residues, and waste products from farm animals—can be converted by FERMENTATION or pyrolysis to fuels, such as ethanol (ETHYL ALCOHOL), methanol (METHYL ALCOHOL), and METHANE.

Although Germany met a large portion of its fuel needs with synthetic fuels during World War II, the rest of the world largely neglected this source until the prices of petroleum and natural gas rose sharply in the 1970s. The U.S. Synthetic Fuels Corp., a federal agency, was established in 1980 to subsidize private development of synfuel plants. Few plants were actually completed, and their expensive product could not compete with the cheap fuel prices of the oil-glut years. In 1986 the corporation's funding was ended. A few smaller plants show promise of producing less costly, environmentally clean synfuels, however, and the Department of Energy continues to fund synfuels research.

syphilis Syphilis, a sexually transmitted disease, is caused by the SPIROCHETE *Treponema pallidum*. The spirochete cannot survive outside the body, and so contracting the disease by other than intimate contact is rare. The spirochete usually enters the body through invisible breaks in the skin or through intact mucous membranes lining the mouth, rectum, or genital tract. About 3 weeks later, the patient develops a sore, called a chancre, at the entry spot. Relatively painless, it is normally found around the genitalia but is sometimes seen on the lips or mouth, on the breasts, or around the rectum. Lymph nodes in the affected area often become enlarged. The chancre contains large numbers of spirochetes and is highly contagious. Even without treatment, the chancre slowly heals in several weeks; the spirochetes, however, spread throughout the body, and about 6 weeks later the secondary stage of syphilis occurs, characterized mainly by fever, swollen glands, and a painless, nonitching rash over most of the body, including the genital tract, the mouth, and the palms and soles. Lesions also form in the mouth and around the vagina and anus, and these are highly contagious. Symptoms eventually resolve, and the disease enters its latent phase.

Two-thirds of syphilitic patients have no further trouble with the disease and are no longer infectious. Months to years later, however, involvement of the brain and spinal cord occurs in some persons, impairing thinking, sensation, and movement. Some suffer skin and bone damage; in others, blood vessels are damaged, causing heart failure and possibly requiring surgery. Pregnant women may infect the fetus, resulting in miscarriage, stillbirth, or deformities that may not appear until the child reaches puberty. Syphilis can be diagnosed with a blood test, and all stages of the disease can be cured with antibiotics. Damage that has already occurred, however, cannot necessarily be repaired; early diagnosis and treatment are therefore extremely important.

Syr Darya [seer dar-yah'] Syr Darya is a river system in the Tadzhikistan, Uzbekistan, and Kazakhstan republics of the USSR. The headstreams of the Syr—the Naryn River and Kara Darya—begin in the Tian Shan range of China and flow through Kirghizia. From its juncture with the Naryn in the Fergana Valley, the Syr flows west and northwest for 2,137 km (1,328 mi) to its delta at the northeastern corner of the Aral Sea. The river is dammed at the western end of the heavily populated Fergana Valley to provide irrigation for the cotton grown there. Cities in the region include Tashkent, Andizhan, Kokand, and Margilan. Rice is grown in the delta area, which includes the cities of Leninabad and Novokazalinsk. The Syr is not generally navigable because of its unstable course.

Followed by the old caravan route between China and Europe, the Syr is the ancient Jaxartes River, which marked the northeastern boundary of the province of Bactria established by Alexander the Great. Later occupied by nomadic tribes, the area began to come under Russian control during the 18th century.

Syracuse (New York) Syracuse is a city in central New York on the southern end of Lake Onondaga. The seat of Onondaga County, it has a population of 163,860 (1990), and 659,864 persons live in the metropolitan area. A commercial and manufacturing city, it produces chemicals, steel, automobiles, electrical equipment, machine tools, and pharmaceuticals. Educational institutions include Syracuse University (1870), LeMoyne College (1946), and the State University of New York's Upstate Medical Center and College of Forestry. The Everson Museum of Art (1896) is there, and parks include the Onondaga Lake Park and the Erie Canal Park. The New York State Fair is held around Labor Day each year in Syracuse.

The region was the home of the Onondaga tribe, and their village on the site served (*c.*1570–1770) as the center of the Iroquois League. Samuel de Champlain visited the village in 1615. The first white settlers arrived in 1786, and by 1788 they operated sawmills and saltworks along the Lake Onondaga shores. After the city was linked to the Erie Canal in 1825, its economic growth was assured.

Syracuse (Sicily) In ancient times, Syracuse was Sicily's most powerful Greek city. Founded on the east coast of the island by colonists from Corinth about 734 BC, Syracuse grew rapidly, founding in turn the colony of Camarina, on the southern coast, about 589. Syracusan control of much of Sicily was achieved by the tyrants Gelon (r. 485–478) and Hiero I (r. 478–467). Gelon destroyed a mighty Carthaginian army at Himera in 480. After Hiero's death a democracy was installed (466–405); it thwarted (427–424) Athenian attempts at domination and defeated (415–413) the Athenian army and navy in one of the decisive battles of the Peloponnesian War.

Another tyrant, Dionysius the Elder, lifted Syracuse to new heights in the 4th century. He contended with Carthage, reasserted control over Sicily, fought the Etruscans, had dealings with Rome, and created a court famous for its splendor. The troubled reign of his son, Dionysius the Younger, who studied with and rejected Plato, ended in 345, when Timoleon reintroduced an ephemeral democracy. Agathocles became king in 304.

Syracuse declined in the 3d century BC. Although Pyrrhus fended off the Carthaginians (278–275) and Hiero II (r. *c.*270–215) enjoyed a long and prosperous rule as a Roman ally, after Hiero's death Syracuse became allied with Carthage, Rome's adversary in the Punic Wars. Rome besieged faction-torn Syracuse, compelling its surrender in 212. Syracuse then became capital of the province of Sicily and enjoyed relative prosperity. It was ravaged by the Franks in AD 280, became Muslim in the 9th century, and was conquered by the Normans 200 years later.

Modern Syracuse (1989 est. pop., 124,400) is the capital city of Syracuse province. The older section is mostly on the small island of Ortygia, connected to the newer areas by a causeway. The city has two harbors and is a busy fishing port; other industries are salt processing, tourism, wine making, and the manufacture of cement and soap.

Syracuse University Established in 1870 by the Methodist Episcopal Church, Syracuse University is an independent coeducational institution in Syracuse, N.Y. Among its divisions are the Newhouse School of Public Communications, the New York College of Forestry (a unit of SUNY), the Maxwell School of Citizenship and Public Affairs, and independent affiliate Utica College, in Utica. University College, the adult education division, offers courses in several off-campus centers.

Syria The Syrian Arab Republic is bordered by Turkey, Iraq, Jordan, Israel, Lebanon, and the Mediterranean Sea. This strategic crossroads location and Syria's military power give it an importance within the Middle East that is out of all proportion to its size and economic potential and have involved it in many of the region's key political problems. Syria is a modern state in an ancient land. Although its contemporary boundaries were created by France after World War I, the name *Syria* has been applied to the larger eastern Mediterranean littoral region for centuries.

Land and Resources

Much of the country consists of relatively flat desert. A series of hills and mountain ranges roughly parallel the narrow coastal plain, including the Jebel al-Druze and the Anti-Lebanon Mountains, where Mount Hermon, the highest point in the country, rises to 2,814 m (9,286 ft). Most of the interior consists of a plateau, across which a line of hills runs from southwest to northeast. In the southeast is the Syrian Desert.

The Mediterranean moderates temperatures along the coastal plain, where temperatures typically range from 7° C (45° F) in January to 27° C (80° F) in August, and normal annual rainfall varies from 750 to 1,000 mm (30 to

AT A GLANCE

SYRIAN ARAB REPUBLIC

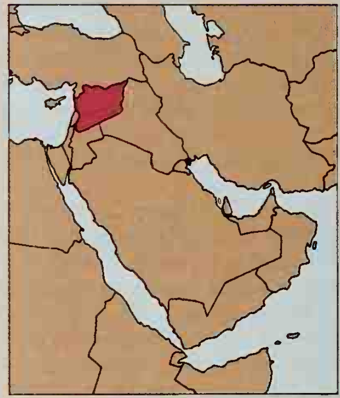
Land: Area: 185,180 km^2 (71,498 mi^2). Capital and largest city: Damascus (1989 est. pop., 1,361,000).

People: Population (1990 est.): 12,483,440. Density: 67 persons per km^2 (175 per mi^2). Distribution (1989): 50% urban, 50% rural. Official language: Arabic. Major religions: Islam, Christianity.

Government: Type: republic. Legislature: People's Assembly. Political subdivisions: 13 governorates and 1 municipality.

Economy: GNP (1989): $12.44 billion; $1,020 per capita. Labor distribution (1986): agriculture—30%; industry and construction—29%; public administration and services—22%; transport and trade—18%. Foreign trade (1988 est.): imports—$1.9 billion; exports—$1.3 billion. Currency: 1 Syrian pound = 100 piastres.

Education and Health: Literacy (1986): 61% of adult population. Universities (1989): 4. Hospital beds (1988): 13,505. Physicians (1988): 8,420. Life expectancy (1990): women—70; men—68. Infant mortality (1990): 38 per 1,000 live births.



40 in). Most of Syria, however, receives less than 250 mm (10 in) of rainfall a year, and a good portion receives less than 100 mm (4 in). Winters in the interior can be cold; in the north, temperatures often fall below freezing. Summers are hot, particularly in the east; daily maximum temperatures exceed 40° C (100° F) over much of the interior between June and August.

Few large rivers originate within Syria; the EUPHRATES, al-Khabur, and Balikh have their headwaters in Turkey, and the Orontes rises in Lebanon. Tapping these rivers, particularly the Euphrates, for irrigation has been a development priority.

Fertile soils are found in the north, along the coast, and in the river valleys. Much of the natural vegetation has been depleted by human activities. Native wildlife includes gazelles, antelopes, deer squirrels, wildcats, hares, and various birds and small desert reptiles. The chief mineral resources are phosphates and petroleum, although Syria is not a major petroleum producer by Middle East standards.

People

Arabic is the mother tongue of 85–90% of the population (see ARABS; ARABIC LANGUAGE). KURDS are the largest linguistic minority (9%). There are also small communities of Armenians, Circassians, Turks, and Aramaic-speakers. These minorities are largely bilingual in Arabic. Religious differences remain politically and socially significant. Although 85% of all Syrians are Muslims, they belong to different sects. Roughly 70% are SUNNITES; the remainder are SHIITES, Ismailites (see ISMAILIS), Alawites and DRUZES. Since 1963, Alawites have played a prominent political role because of their overrepresentation in the military and the BAATH PARTY. The non-Muslim population is largely Christian, particularly Greek Orthodox, and is concentrated in Damascus and Aleppo. Syria is also host to about 260,000 Palestinian refugees.

The availability of water largely determines where people live. Population densities are highest along the coast between Latakia and Tartus, in a north-south belt that links the cities of ALEPPO, HAMA, HOMS, and DAMASCUS (the capital), and in the river valleys east of Aleppo. Only a few nomadic BEDOUINS live in the desert to the south and east. The population is growing by almost 4% annually, and cities are growing even more rapidly because of migration from rural areas.

The population is well educated by Middle Eastern standards. Educational facilities at all levels have expanded greatly since the mid-1960s. Access to health services has improved, but a disproportionate share of hospitals and personnel remain concentrated in Damascus.

Economic Activity

Agriculture dominated the Syrian economy until recently. Less than one-third of the land is cultivated because of the unfavorable environment. Wheat and barley account for two-thirds of the cultivated area. Cotton, the major cash crop, was the leading export until the mid-1970s. Other crops include vegetables, citrus fruits, olives, tobacco, and sugar beets. Peasants often also herd sheep or goats.

Most of Syria's earliest industries processed agricultural products or turned out light consumer goods. In the 1970s the government initiated a policy of rapid industrialization, particularly in such areas as iron and steel, fertilizers, and chemicals and the assembly of such items as refrigerators and television sets. As a result, industrial output has been increasing by more than 10% annually.

Petroleum accounts for about 70% of total exports. Because much of Syria's oil is heavy and high in sulfur, it imports light crude oil from Iran for blending in refineries at Homs and Baniyas. Substantial phosphate deposits form the basis of the fertilizer industry. The public sector accounts for three-fifths of the GDP, although the private sector has been encouraged to play an active role in the economy.

The Syrian economy suffered severely in the past from a poor transportation system, but modern ports have been developed at Latakia and Tartus, and all major cities are now connected by an extensive rail network and modern highways. Rapid industrialization and an ambitious program to electrify the countryside have led to power shortages despite a great increase in power production since 1973.

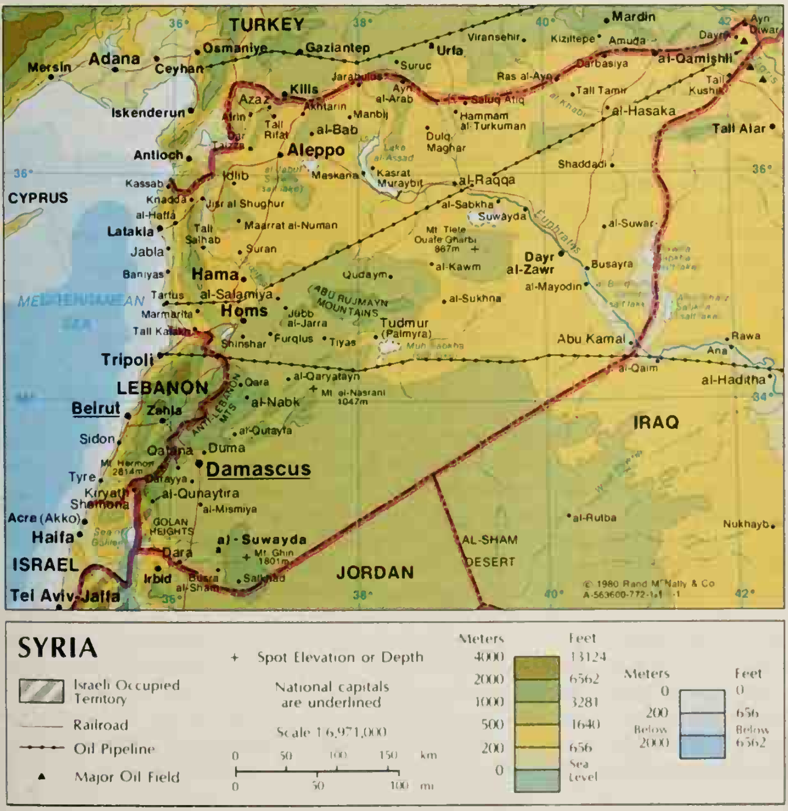
Syria is nominally socialist and has close political and military ties with the USSR, but it obtains most of its nonoil imports from Western Europe and Japan. Romania, Italy, and the USSR are the chief export markets. The country consistently has a balance-of-trade deficit.

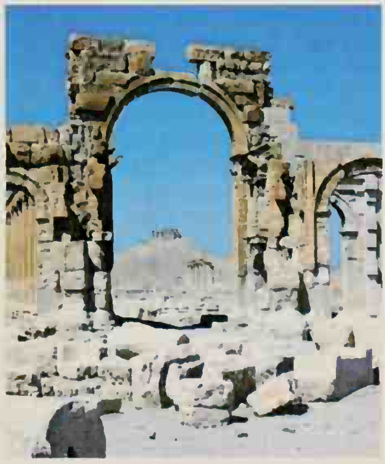
Government

According to the 1973 constitution, power is divided among the executive, legislative, and judicial branches. In practice, power is highly centralized in the president, who appoints all cabinet ministers; he is also general secretary of the ruling Baath party and commander in chief of the armed forces. Not all members of the elected People's Assembly belong to the Baath party, but there is no real opposition, and the assembly lacks independent power. The Baathist regime ultimately depends on military backing. Key collective decisions are made by the regional command of the Baath party or the military high command.

History

Although the modern Syrian state was not established until after World War I, recent excavations at EBLA indicate the existence of a large state in the 3d millennium BC that traded with the better-known Nile valley and Mesopotamian civilizations, and artifacts at Tell Leidan in the north date back to 5000 BC. Damascus claims to be the





Now in ruins, Palmyra, an ancient caravan stop in central Syria, became a vital link in east-west commerce during the era of Roman rule.

Damascus, in southwestern Syria, is possibly the oldest permanently inhabited city in the world. Several of history's great generals, including King David of Israel, Alexander the Great, and the Mongol leader Timur, have either sacked or occupied Damascus to control its strategic location along the Middle Eastern trading routes.

world's oldest continuously settled city.

The historic region known as Greater Syria (comprising present-day Syria, Lebanon, Israel, and Jordan) was a frequent object of conquest because of its location on the main trade and invasion routes between the Mediterranean and Mesopotamia and southwestern Asia and northeastern Africa. Various Semitic peoples, including Phoenicians, Canaanites, Hebrews, Aramaeans, and nomadic tribes from the Arabian Peninsula, settled the region, which was successively ruled by the Egyptians, Hittites, Assyrians, Persians, and Greeks before being incorporated into the Roman Empire in 63 BC. When the empire was divided in the 4th century AD, Syria became part of the BYZANTINE EMPIRE.

The most important and lasting conquest was by Muslim Arab armies in AD 633–40, following the rise of Islam in the Arabian Peninsula. Subsequently, Syria was converted to Islam and gradually Arabized. Damascus became the capital of the Muslim Arab UMAYYAD empire between 661 and 750. After the overthrow of the Umayyad dynasty, the area was controlled by the Baghdad-based ABBASIDS or by various Cairo-based Muslim dynasties. The seizure of Syria by the SELJUKS in the 11th century was a precipitating factor in the CRUSADES. SALADIN expelled the Europeans late in the 12th century. From the mid-13th to the early 15th century Syria was ruled by the MAMELUKES, although it was greatly weakened by MONGOL incursions.

Conquered by SELIM I in 1516, Syria was part of the OTTOMAN EMPIRE until World War I, when growing Arab nationalism and opposition to Turkish control fueled a British-backed Arab rebellion. After the expulsion of the Turks from Syria in 1918, Britain and France divided the central Middle East, creating Syria and other new states. The League of Nations formally approved the French mandate over Syria in 1922. In 1946, after a long struggle, full independence was attained.

Between 1949 and 1963 there were frequent changes of government and many military coups. This instability resulted partly from the perceived illegitimacy of the state, whose existence was seen as an obstacle to achieving Arab unity. Because of Syria's commitment to pan-Arabism, it involved itself deeply in regional affairs and inevitably got caught up in the vortex of inter-Arab rivalries. Various plans for union with Iraq were unsuccessful, and the 1958 merger of Egypt and Syria to form the UNITED ARAB REPUBLIC collapsed in 1961. The continuing dispute with Israel (in which Syria has played a prominent role) and the intrusion of the cold war into the region were also disruptive. Finally, Syria suffered from deep regional, sectarian, class, and ideological cleavages manifested in a series of complex power struggles, the most important of which was waged between the conservative and traditional elite and a rising salaried middle class and peasantry pressing for modernization. The Baath party, the best-organized advocate of change, won growing support.

The military coup that brought the Baath party to power in 1963 was a major turning point in Syrian history. Land reform and extensive nationalization redistributed wealth and undermined the power base of the traditional ruling class. A disproportionate number of the new elite were young Alawite officers from remote rural areas and small towns. Syria has enjoyed relative stability since 1963, although intraparty disputes have at times been bitter. A coup in 1966 marked the ascendance of the radical socialist neo-Baath under Salah Jadid. This regime's unpopularity and the loss of the Golan Heights to Israel during the 1967 ARAB-ISRAELI WAR contributed to the 1970 coup that brought Hafez al-ASSAD to power.

During the early 1970s, Syria experienced rapid economic growth fueled by rising oil prices. Assad's domestic stock also rose after the 1973 Arab-Israeli War, in which Syrian forces performed creditably. After the mid-1970s, however, the regime's problems mounted. Syria has long been deeply involved, militarily and politically, in the turmoil in neighboring Lebanon (where it has, at various times, supported different factions). It also seeks strategic parity with Israel. Military expenditures have therefore been a heavy burden, despite substantial assistance from other Arab countries and the Soviet Union, with which Syria signed a treaty of friendship in 1980. Discontent over the country's economic performance was aggravated by political and religious differences, corruption, and the perceived Alawite monopolization of power. In 1976, Muslim fundamentalist organizations began a wave of assassinations and bombings. The regime resorted to harsh repression, especially during large-scale disturbances in Aleppo in 1980 and an insurrection in Hama in 1982 in which several thousand civilians were killed.

Assad, who was elected to a fourth seven-year term as president in 1991, skillfully used both force and diplomacy to make his country a significant power in the Middle East but became increasingly isolated in the Arab world in the 1980s because of his support of non-Arab Iran in the IRAN-IRAQ WAR (1980–88) and his backing of radical Palestinians seeking to oust Yasir Arafat as head of the PALESTINE LIBERATION ORGANIZATION (PLO). Several Western nations imposed sanctions on Syria in the mid-1980s, charging that it was deeply involved in international terrorist activities. Opposed to separate negotiations with Israel, Assad condemned the 1979 Egyptian-Israeli peace treaty; the 1983 Israeli-Lebanon peace accord was canceled primarily because of his refusal to meet its conditions.

A 1989 Syrian-brokered peace accord in war-torn Lebanon, where Syrian forces remain entrenched, appeared to take hold in the early 1990s. In 1990, Syria resumed diplomatic ties with Egypt (broken off in 1977). It was among the Arab countries joining the U.S.-led multinational force that expelled Iraq from Kuwait in the 1991 GULF WAR. Both the Lebanon accord and Syria's role in the Gulf war contributed to the nation's reemergence as a major regional power. In 1992, Israel indicated that it might exchange land for peace with Syria.

Syrian Desert The Syrian Desert covers southern Syria, northeastern Jordan, western Iraq, and northern Saudi Arabia. Mostly a rock- and gravel-covered plateau, it receives an average of 125 mm (5 in) of rain a year and has July temperatures above 38° C (100° F). Wadis flow east toward the Euphrates River, but few reach it. Cacti and grasses are the main plants; animals include gazelles, jackals, and hares. BEDOUIN nomads raise goats, sheep, and Arabian horses. At oases, grapes, olives, and figs are grown. PALMYRA was the principal junction of caravan routes across the desert by AD 250.

syringomyelia [suh-ring'-goh-my-ee'-lee-uh] Syringomyelia is a chronic disease in which the spinal cord is damaged by the formation of fluid-filled cavities (syrinxes) and the replacement of nervous tissue by scar tissue. The disease, whose cause is unknown, is accompanied by disturbances of motor and sensory function. The spinal-cord cavities can extend through a considerable section of the cord; the symptoms depend on which section of the spinal cord is affected. Often the first symptoms are weakness and wasting of muscles of the upper extremities and burning sensations or loss of pain sensation in the lower arms. Syringomyelia usually progresses over many years. No satisfactory treatment has been found, although some physicians advocate surgical drainage of the syrinxes.

systems engineering *Systems engineering* is a general term that describes the application of engineering skills to the total design and creation of a complex system. A system is defined as a set of concepts or parts that must work together to perform a particular function.

The basic concepts of systems engineering have been in use for centuries. The term, however, was not formally used, nor was the importance of the concepts recognized, until after World War II, when the complexity of systems increased sharply.

The major steps in the completion of a typical systems-engineering project are the following: (1) problem statement; (2) identification of objectives; (3) generation of alternatives; (4) analysis of these alternatives; (5) selection of one of them; (6) creation of the system; and (7) operation.

Problem statement is extremely important, because it provides the basis for determining the objectives and the alternatives that are to be considered. Next, the objectives must be identified. These objectives will also become the basis for evaluating alternatives in the later phases of the engineering study.

Alternatives are then generated so that many feasible approaches can be considered. The alternatives are analyzed to predict how they would perform if they were actually implemented. The analysis often uses mathematical models investigated by computer (see COMPUTER MODELING; COMPUTER-AIDED DESIGN AND COMPUTER-AIDED MANUFACTURING). The performance of the alternatives must be evaluated on the basis of the objectives identified earlier.

Once the basic system design has been selected, the systems engineers must define and analyze it in sufficient detail to provide instructions for its construction. Finally, the system must be installed and operated.

Szasz, Thomas [sahs] Psychiatrist, neurologist, and educator Thomas Stephen Szasz, b. Hungary, Apr. 15, 1920, became a U.S. citizen in 1944 and received his M.D. from the University of Cincinnati the same year. After a series of distinguished psychiatric residencies at various hospitals and medical colleges, Szasz became professor of psychiatry at the University of Syracuse. *The Myth of Mental Illness* (1961) brought Szasz national recognition and became the foundation of contemporary work in humanistic psychiatry.

Szasz believes that what traditional psychiatry terms *mental illnesses* are not illnesses at all but fundamental problems in living that produce behaviors directly related to interactions of the individual with his or her family, surroundings, and society. Such problems therefore cannot be classified in terms of a medical conception of illness but must be understood in terms of the deceptions, confusion, and misinterpretations arising in a specific situational setting against which the individual develops certain defense mechanisms—such as schizophrenia—for his or her social and emotional survival. Szasz, together with R. D. LAING, is a forerunner of the "radical" or humanistic movement in psychiatry, which is also characterized by opposition to involuntary confinement and other considerations regarding the human and civil rights of patients.

Szczecin [shet'-seen] Szczecin (German: Stettin), one of Poland's leading port cities, lies on the Oder River about 50 km (30 mi) from the Baltic Sea. An important commercial and industrial center, the city has a population of 396,600 (1988 est.). The port is the economic mainstay, and coal from Silesia is the major export. Other industries include the production of foodstuffs, textiles, and chemicals and shipbuilding. Szczecin has several colleges, museums, and theaters, and its most notable landmark is the 12th-century Saint Peter and Saint Paul's Church (restored in 1816). By the 8th century a Slavic fishing village was on the site. It was the largest town of Pomerania by the 12th century, serving as its capital until 1637. It joined the Hanseatic League in 1360. Part of Sweden from 1648 to 1720, Szczecin passed to Prussia in 1720. It remained under German rule until 1945, when it was annexed to Poland. At that time the German population was evacuated.

Szechwan see SICHUAN

Szeged [seg'-ed] Szeged, a city in southern Hungary, lies on the Tisza River, near the Yugoslav border, about 160 km (100 mi) southeast of Budapest. The population is 189,484 (1989 est.). Best known for red and green paprika, grown in the surrounding region, and for salami, Szeged also manufactures wood and leather products, chemicals, textiles, glass, and furniture. The Votive Cathedral (1919–29) has an organ with more than 12,000 pipes. The ruins of a 13th-century tower are a major landmark. The city has two universities. A military stronghold and a salt-trade center from the 10th to 15th centuries, Szeged came under Turkish rule during the mid-16th century. In 1879 a flood devastated the city, but it was rebuilt.

Szell, Georg [sel] The conductor Georg Szell, b. Budapest, June 7, 1897, d. July 30, 1970, raised the Cleveland Orchestra to international stature. From 1917 to 1939, he held conducting positions in Strasbourg, Prague, Berlin, and Glasgow. He settled in the United States in 1939. Aside from guest appearances and a brief period (1942–45) with the Metropolitan Opera, he concentrated on developing (1946–70) the Cleveland Orchestra. He was opposed to subjective interpretations, convinced that a composer's expression was best conveyed through a clear and precise rendering of the score.

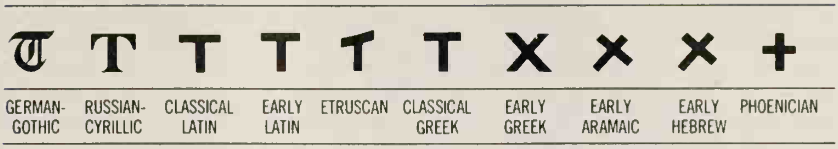
Szigeti, Joseph [sig'-et-ee] The great Hungarian violinist Joseph (Joska) Szigeti, b. Sept. 5, 1892, d. Feb. 19, 1973, studied with Jenö Hubay in Budapest, where he made his debut in 1902 at the Royal Academy of Music. His first commercial recordings date from 1909, and his art is well documented by the phonograph. In 1940 he settled in the United States, becoming a citizen in 1951. Renowned for lucid and intense performances of Bach, Mozart, Beethoven, and Brahms, Szigeti was also an ardent champion of modern works: the names of Busoni and Bartók, with whom he often appeared, and of Stravinsky, Prokofiev, and Bloch figured prominently in his programs. His playing was as remarkable for its elegance and color as for its intelligence.

Szilard, Leo [sil'-ahrd] The Hungarian-born American physicist and biologist Leo Szilard, b. Feb. 11, 1898, d. May 30, 1964, made significant contributions to the development of the atomic bomb. Hearing of Otto Hahn's demonstration of uranium fission, Szilard was certain that the sustaining of a chain reaction would be possible. He helped draft the letter from Albert Einstein to President Franklin Roosevelt that ultimately resulted in the decision to proceed with the atomic bomb. Szilard later turned his attention toward the problems nuclear weapons posed, and he shared the 1959 Atoms for Peace Award with E. P. Wigner. His experimental work in molecular biology led to theories of mutations and the aging process.

Szold, Henrietta [zohld] A leader in international social service and education, Henrietta Szold, b. Baltimore, Md., Dec. 21, 1860, d. Feb. 13, 1945, was the founder and first president of HADASSAH, the women's Zionist organization responsible for upgrading health care in Palestine. She was a cofounder of the Jewish Publication Society of America and served as an editor for the *American Jewish Yearbook* (1892–1916) and the *Jewish Encyclopedia*. Szold, the first woman member of the World Zionist executive, lived in Palestine after 1920 and worked to establish harmony between Jews and Arabs, advocating a binationalist state.

Szymanowsky, Karol [shim-ahn-awf'-skee] Karol Szymanowsky, b. Oct. 6 (N.S.), 1882, d. Mar. 29, 1937, was the foremost Polish nationalist composer of his time. Born to a wealthy family, he studied composing at an early age with Sigismund Noskowski. He was often torn between a cosmopolitan international career and his commitment to Poland's national culture. A prolific and intense composer, Szymanowsky was influenced by the Romantic styles of Wagner, Richard Strauss, and Max Reger until about 1910, when he came under the influence of the French impressionist styles of Debussy and Ravel. From 1920, however, he adopted a simpler style inspired largely by Polish folk idioms. His compositions include three symphonies; two violin concertos; numerous piano pieces (extending the traditions of Chopin and Scriabin); pieces for various chamber-music ensembles; songs; choral works, including a *Stabat Mater* (1925–26); the folk ballet *Harnasie* (1922–32); and two operas.

Tt



T *T/t* is the 20th letter of the English alphabet. Both the letter and its position in the alphabet were derived from the Latin, which derived it from the Greek by way of the Etruscan. The Greeks, who call the letter *tau*, took the name, form, and position of the letter from a Semitic writing system, in which the name of the sign was *taw*; it was the last letter of their alphabet. The sound of *T/t* is usually classified as a voiceless dental stop. In modern English speech it is the voiceless counterpart of *d* and is made not with the tongue against the upper front teeth but with the tongue against the ridge behind the teeth, as in *top* or *post*. *T/t* also represents other sounds, such as *ch* in *nature* and *sh* in *partial* or *nation*; in some words, such as *listen*, it is silent. When *t* is followed by *h* in the same syllable, the combination is either voiceless or voiced; in a few words, such as *Thomas* or *Thames*, it is pronounced as simple *t*.

T Tauri stars see VARIABLE STAR

Ta-lien see Dalian

Taafe, Eduard, Graf von [tah'-fe] During the reign of Austrian Emperor Francis Joseph, the longest term as premier was served by Eduard, Graf von Taafe, b. Feb. 24, 1833, d. Nov. 29, 1895. Taking office in 1868, Taafe advocated political concessions to the Czechs similar to those accorded Poles and Hungarians. This position lost him the support of the German majority of his government and led him to resign early in 1870. Taafe again became premier in 1879, and long held the support of the Catholic church and of Poles and Czechs in the Reichsrat. Later, however, his programs fell short of the demands of the nationalistic Czechs, and he was forced to resign in 1893.

Tabari, al- [tah-bah'-ree, ahl] The Muslim scholar Abu Jafar Muhammad ibn Jarir al-Tabari, *c.*839–923, wrote a massive compendium, known as the *Tafsir*, of commentary on the Koran; his *Tarikh al-Rusul wa al-Mulak* (History of Prophets and Kings; portions of which have been translated into English) is the first history of the world in Arabic.

Tabasco Tabasco, a state in southeastern Mexico on the Bay of Campeche, has an area of 25,267 km^2 (9,756 mi^2) and a population of 1,501,183 (1990). Its capital is Villahermosa. The low, flat territory is covered by swamps, lagoons, and rain forests and is crossed by numerous rivers. Predominantly agricultural, Tabasco is known for its tropical produce, which includes cacao, sugarcane, bananas, pineapples, vanilla, and chicle. Since the 1960s, petroleum extraction has become important. Explored by Juan de Grijalva in 1518, Tabasco was conquered by Francisco de Montejo in 1530. It became a state of independent Mexico in 1824.

tabernacle According to certain passages in the biblical Book of Exodus (chaps. 25–31, 35–40), the tabernacle was a portable sanctuary constructed by Moses where the Israelites worshiped during their wilderness wanderings. The most important part of the rectangular, hide-covered structure was the Holy of Holies, which held the sacred ARK OF THE COVENANT. Another passage in Exodus (33:7–10) describes the tabernacle simply as a "tent of meeting" set up outside the camp as a place for consulting with Yahweh.

Tabernacles, Feast of The Feast of Tabernacles (or Booths), Sukkoth in Hebrew, is one of the three joyous pilgrim festivals of Judaism prescribed in Scripture. It marks the end of the harvest season—specifically, the vintage and fruit harvest in the Holy Land—and is celebrated for 8 or 9 days in late September or early October, Tishri 15–22 or 23 in the Jewish calendar. Its characteristic feature is the erection of a booth (sukkah) covered with greens and decorated with products of the harvest, the top of which is thatched lightly enough so that the sky is visible. Another characteristic observance is the use of four plants—citron, palm, myrtle, and willow—as a festal bouquet. They are carried in procession around the synagogue and are waved during the singing of psalms.

Table Mountain Table Mountain, 1,082 m (3,549 ft) high, lies south of Cape Town, South Africa. It is frequently shrouded by a cloud, "the Tablecloth," which is responsible for the heavy rainfall and luxuriant tropical growth on its flat summit.

table tennis Table tennis, also known as Ping-Pong, is a game for singles or doubles competition. The object

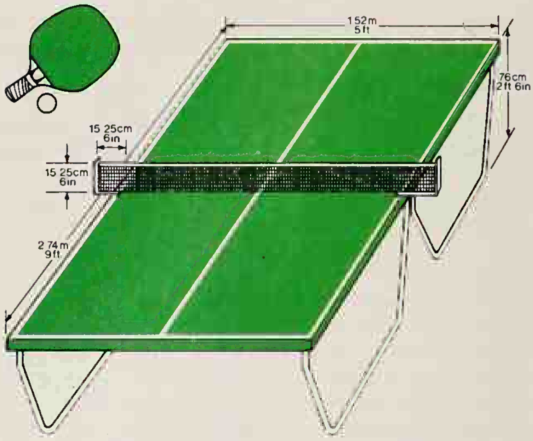


Table-tennis players use paddles to hit a small ball across a table divided by a fine mesh net. The net extends beyond the side boundaries of the playing surface so that participants return wide-angle shots over the net.

of the game is to hit a small ball over a net stretched across a table so that it hits the opposite side of the table. Points are scored when one player fails to return the ball over the net so that it bounces on the opponent's side. The ball is put into play with a serve, and each player has five consecutive turns serving.

A table-tennis table is 9 ft (2.7 m) long and 5 ft (1.5 m) wide, and 2.5 ft (76 cm) above the ground. The net is 6 in (15.2 cm) high and stretches 6 ft (1.8 m) across the table so that it overlaps the edges 6 in. on each side. The table-tennis paddle may be any size, shape, or weight; the only restriction is on the thickness of the rubber-and-sponge striking surface. This may be no more than 2 mm (0.08 in) thick. Occasionally paddles are given a striking surface of pimpled rubber or sandpaper. The table-tennis ball has a diameter of 1.5 in (3.8 cm) and should weigh 37–39 gr (2.4–2.5 g). The ball is made of celluloid (or a plastic material with similar characteristics) and has a white matte surface.

A game is to 21 points; if the score reaches a 20-point tie, then the first player to achieve a 2-point lead wins. In local competitions, a set is the best of three games; in international competitions, it is the best of five games.

Although it is a comparatively modern game, table tennis is of obscure origin. The game enjoyed surges of popularity before and after World War I.

tabloid see NEWSPAPER

taboo Taboo is a powerful restriction or prohibition that regulates contacts between specific categories of individuals and things in particular circumstances. Taboos are backed by social sanctions or penalties. Some supernatural force is always invoked as authority for the sanction. Taboos reflect a society's understanding of its own order and that of the universe. They caution against contacts that might violate approved social behavior. There exists a nearly universal taboo against INCEST, and taboos concerning foods that are not to be eaten are common in all parts of the world. Other frequent subjects of taboo are menstrual blood and the dead.

The term *taboo* originated in POLYNESIA, where *tapu* (taboo) played a prominent part in the regulation of society. Among the New Zealand MAORI, taboos ranged from those intimately associated with spirit beings, such as the taboo concerning certain lizards believed to embody evil spirits, through those connected with the sanctity of chiefs, down to taboos placed on land or other possessions to ensure their treatment as the property of a particular individual or group.

Tabor, Horace W. [tay'-bur] Horace Warner Tabor, b. Holland, Vt., Nov. 26, 1830, d. Apr. 10, 1899, was a U.S. mining developer who made a fortune eventually worth $9 million from Colorado's Matchless Mine and other mining enterprises. Tabor first worked as a stonecutter and a farmer in Vermont. He joined (1859) the Pikes Peak gold rush, and opened a store in a Colorado mining area. There he grubstaked prospectors and became wealthy in 1878, when two men he had staked found a silver lode. He entered politics, becoming lieutenant governor of Colorado (1879–83). Tabor lost his fortune during the panic of 1893, and he became (1898) a postmaster in Denver.

Tabor, Mount Mount Tabor (Hebrew: Har Tavor) rises 588 m (1,929 ft) above the Plain of Esdraelon, 8 km (5 mi) east of Nazareth, in northern Israel. The stratified limestone mountain has been a landmark since ancient times. First referred to in the 13th century BC in Egyptian documents, it was frequently mentioned in the Old Testament. Christian tradition places the Transfiguration of Jesus there.

Tabriz [tah-breez'] Tabriz, the capital of the province of East Azerbaijan, Iran, lies in the extreme northwest of the country, about 130 km (80 mi) south of the Soviet border. The population—971,482 (1986)—is mostly Azerbaijani, although there is a Kurdish minority. The city is said to have derived its name from the nearby hot springs. Famous for its carpets, Tabriz manufactures textiles, leather goods, soaps, paints, and dried fruits and nuts. A railroad connecting Tehran with the USSR passes through the city, which is also a highway junction. Landmarks include the 15th-century Blue Mosque and the citadel or Ark (actually the 14th-century mosque of Ali Shah). The University of Azarabadegan (1949) is there.

Geology and geography have made Tabriz a victim of earthquakes (in 791, 858, 1041, 1721, and 1780) and of repeated conquests. Dating back to about the 3d century AD, the city was the capital of the Mongol khans in the 13th and early 14th centuries. In 1382, Tabriz was taken by Timur, the Turkic conqueror. Long disputed between the Ottoman and Persian empires, it became part of Persia in 1618, although the Turks occupied the city from 1721 to 1730, and the Russians from 1827 to 1828 and then from 1945 to 1946.

Taché, Sir Étienne Paschal [tah-shay'] Sir Étienne Paschal Taché, b. Saint-Thomas, Lower Canada (now Montmagny, Quebec), Sept. 5, 1795, d. July 30, 1865, was a Canadian political leader. Taché was elected to the United Canada legislature in 1841 and appointed commissioner of public works in 1848; he was a member of the legislative council from then until 1864. He was copremier of Canada with Allan N. MACNAB (1856) and John A. MACDONALD (1856–57). In 1864, Taché, again copremier of a coalition government with Macdonald, presided over the Quebec Conference, which paved the way for confederation.

tachometer [tak-ahm'-uh-tur] A tachometer is an instrument that displays the speed of an engine (the angular rate at which the crankshaft is turning) in revolutions per minute (rpm), allowing the driver of an automobile to select the appropriate gear for a desired combination of road speed and engine speed. A tachometer dial's upper limit—called the redline—indicates the maximum speed at which the engine should be run. A tachometer is also useful in tuning an engine, because many engine parameters vary with varying rpm and should be set at a particular engine speed.

Tacitus, Cornelius [tas'-i-tuhs] Cornelius Tacitus, AD *c.*56–*c.*115, a Roman senator and one of the greatest Roman historians, lived through the tyrannical rule of Domitian and the golden age of Trajan. He was praetor (88), consul (97), and governor of the province of Asia (*c.*112). His short monographs *Germany* (98) and *Dialogue on Orators* (between *c.*98 and 102) and the eulogy *Life of Agricola* (98) are important sources for knowledge about ancient Germany, Roman oratory, and Roman Britain. His two major works, the *Annals* and the *Histories,* cover the period from the death of Augustus (AD 14) to the death of Domitian (96). Today about one-third of the *Annals* is missing; the surviving four and one-half books of the *Histories* go only to the beginning (69–70) of Vespasian's reign and deal with the civil war after the death of Nero.

Tacna-Arica Dispute [tahk'-nuh uh-ree'-kuh] The Tacna-Arica Dispute was a long-standing quarrel between Peru and Chile over the ownership of two border provinces, Tacna and Arica. After Chile defeated Bolivia and Peru in the War of the Pacific (see PACIFIC, WAR OF THE), it controlled the southernmost portion of Peruvian territory. After the Treaty of Ancón, ratified in 1883, Peru and Chile agreed that a plebiscite would be held in Tacna and Arica after 10 years of Chilean occupation. The plebiscite never took place, however, because the two countries could not agree on terms. The resulting tension led to broken diplomatic relations in 1910. Finally, in 1928, Peru and Chile agreed to let U.S. secretary of state Frank Kellogg suggest an alternative to the plebiscite. The terms of the resulting agreement, signed June 3, 1929, assigned Tacna to Peru and Arica to Chile. In addition, Chile paid Peru an indemnity of $6 million and agreed to let Peru use Arica's port and transport facilities.

Tacoma [tuh-koh'-muh] Tacoma is a city in west central Washington on Puget Sound where the Puyallup River enters Commencement Bay. The seat of Pierce County and the state's third largest city, Tacoma has a population of 176,664 (1990), with 586,203 persons in the metropolitan area. It is also a major seaport, with a fine natural harbor; a railroad terminus; and a major center for lumbering, forest products, and shipbuilding. Tacoma is linked to the Olympic Peninsula by the Tacoma Narrows Bridge (1950), one of the longest suspension bridges in the United States.

Although the site of Tacoma was settled in 1852, it was not until 1868 that Gen. Morton Matthew McCarver developed the settlement as Commencement City. It was later named Tacoma (Indian for "Mount Rainier"). Rapid growth followed the arrival of the Northern Pacific Railway in 1887.

tactics, military see STRATEGY AND TACTICS, MILITARY

Tadzhikistan [tuh-jik'-is-tan] Tadzikistan, spelled Tajikistan since becoming an independent country in 1991, was one of the 15 constitutent republics of the USSR. Located in Central Asia, it has an area of 143,095 km^2 (55,249 mi^2) and a population of 5,210,000 (1992 est.). It borders Afghanistan on the south, Uzbekistan on the west and north, Kyrgyzstan on the north, and China on the east. The capital is DUSHANBE, with a population of 595,000 (1989).

Tajikistan is mountainous and encompasses the PAMIRS—the highest mountains in the former USSR. The climate varies with elevation from cold highlands to hot desert in the piedmont plains.

The Tajik, who account for 62% of the population, are an Iranian-language group of Muslim religion, akin to the neighboring Afghans and to the Persians. Approximately 4,100,000 Tajik live in Afghanistan. Mountain farmers and herders, the Tajik are noted for their irrigated terraces, gristmills, and unirrigated grainfields. Bread, fish, fowl, nuts, fruit, rice, and dairy products are eaten. Women play an important role in the life of the Tajik and are seldom veiled.

Russians constitute 8% of Tajikistan's population and live almost entirely in cities. The second most populous city is Khudzhand (formerly Leninabad; 1989 pop., 153,000). Other major cities are Kulyab and Kurgan-Tyube.

Uranium is mined at Taboshar and processed at Chkalovsk near Khudzhand. Electric power generated by the

Nurek hydroelectric station on the Vakhsh River supports an aluminum industry at Tursunzade (formerly Regar) and a chemical industry at Yavan. The republic is also a major cotton-growing area. Tajikistan is a poor country, however; its per-capita income was the lowest of all the Soviet republics.

The region that is now Tajikistan belonged to the emir of Bukhara before passing to Russian control in the 1880s. After the assumption of power by the Soviets, it was constituted as an autonomous republic in 1924 and was raised to union republic status in 1929. Tajikistan has undergone ethnic and political turbulence since 1990. In late 1992, after many violent clashes, an Islamic coalition finally forced President Rakhman Nabiyev, a former Communist, to resign.

Taegu [te'-goo] Taegu (1990 pop., 2,228,834), the third largest city of South Korea, lies about 250 km (155 mi) southeast of Seoul. One of the country's main market cities and historically the economic and cultural center of southeastern Korea, Taegu manufactures textiles and metal products. Kyungpook National University (1946) and Yeungnam University (1967) are located there. During the Yi dynasty (1392–1910) Taegu was an administrative city.

Taejon [ty-juhn] Taejon, a city in South Korea, lies about 140 km (90 mi) southwest of Seoul. The population is 1,062,084 (1990). A rail junction since the early 20th century, the city is a rice-milling center and produces textiles, chemicals, and machinery. It served as the nation's temporary capital during the Korean War.

taffeta Taffeta is a smooth and usually lustrous fabric made of silk or synthetic fibers. The fabric usually has ribs, made by using heavier or bulkier yarns for the filling, or weft. It was once impregnated with metallic salts to give it a characteristic stiffness. The term *taffeta*, from the Persian *taftah* meaning "to shive" or "to twist," originally described a silk fabric that was used as a luxurious cloth for women's wear. Moiré is taffeta with a watermarked finish.

Taft, Lorado Lorado Taft, b. Elmwood, Ill., Apr. 29, 1860, d. Oct. 30, 1931, was an American sculptor and writer who stood against modernism in sculpture. He simplified nature to stress formal masses in the gigantic *Columbus*, his neo-Renaissance fountain (1912) in front of the railroad station in Washington, D.C., and his enormous cast concrete *Time* (1922) on the fountain in Chicago's Washington Park.

Sen. Robert A. Taft was known as "Mr. Republican" for his advocacy of conservative policies, including the Taft-Hartley Labor Relations Act (1947). His isolationist stance on foreign affairs contributed to his defeats in seeking the party nomination for president in 1940, 1948, and 1952.

Taft, Robert A. Robert Alphonso Taft, b. Cincinnati, Ohio, Sept. 8, 1889, d. July 31, 1953, a son of President William Howard Taft, was a leader of the conservative midwestern wing of the Republican party. He served in the Ohio house of representatives (1921–26), acting as speaker in 1926, and was a member of the state senate (1931–32). A vehement critic of New Deal welfare legislation, Taft won election to the U.S. Senate in 1938. Reelected in 1944 and 1950, he became known as "Mr. Republican."

An isolationist, Taft was a leading opponent of U.S. intervention in World War II before Pearl Harbor was attacked. During the postwar years he favored the containment of Soviet expansionism but opposed most of Harry S. Truman's cold-war measures as too costly and dangerous. Taft was cosponsor of the Taft-Hartley Act (1947; see LABOR-MANAGEMENT RELATIONS ACT), which placed some restrictions on labor unions. A candidate for the Republican presidential nomination in 1940, 1948, and 1952, he lost each time to a representative of northeastern, moderate, internationalist Republicans.

Taft, William Howard William Howard Taft was the 27th president (1909–13) of the United States and the nation's 10th chief justice (1921–30). His presidency was marked by controversy and turmoil amid a growing national reform movement, one that made him a bitter opponent of his old friend Theodore Roosevelt.

Early Life and Career. Taft was born in Cincinnati, Ohio, on Sept. 15, 1857. He was educated at Yale University, where he graduated (1878) second in his class, and at the Cincinnati Law School. In 1886 he married Helen W. Herron.

Taft was appointed (1887) to the Ohio Superior Court and won a 5-year term the next year. President Benjamin Harrison named him solicitor general in 1890. He served (1892–1900) as a federal circuit judge of the Sixth Circuit Court.

In 1900, President William McKinley named Taft to head a commission to end U.S. military rule in the Philippines, which had been ceded to the United States after the Spanish-American War. In this capacity, and as civil

AT A GLANCE

WILLIAM HOWARD TAFT
27th President of the United States (1909–13)

Born: Sept. 15, 1857, Cincinnati, Ohio

Education: Yale College (graduated 1878); Cincinnati Law School (LL.B. 1880)

Professions: Lawyer, Public Official

Religious Affiliation: Unitarian

Marriage: June 19, 1886, to Helen W. Herron (1861–1943)

Children: Robert Alphonso Taft (1889–1953); Helen Herron Taft (1891–1987); Charles Phelps Taft (1897–1983)

Political Affiliation: Republican

Writings: *The Anti-Trust and the Supreme Court* (1914); *The United States and Peace* (1914); *Our Chief Magistrate and His Powers* (1916)

Died: Mar. 8, 1930, Washington, D. C.

Buried: Arlington National Cemetery, Arlington, Va.

Vice-President: James S. Sherman (1909–12)

Wm H Taft

governor (1901–04) of the islands, he headed an efficient and humane administration. He subordinated military to civil command, instituted land reform, sponsored a road-construction program, and, in general, prepared the Filipinos for self-government.

Taft's work in the Philippines resulted in his elevation (1904) to secretary of war in President Theodore Roosevelt's cabinet. The two became fast friends and confidants; by 1906, Roosevelt had chosen Taft as his successor. With Roosevelt's backing Taft won the Republican presidential nomination in 1908 and went on to defeat Democrat William Jennings Bryan.

Presidency. In a certain sense Taft carried on Roosevelt's progressive policies. He instituted and completed more antitrust cases than his "trust-busting" predecessor; he supported the proposed income-tax amendment to the U.S. Constitution; he helped enact a system of postal savings and a measure, the Mann-Elkins Bill, to regulate the railroads more effectively; and he backed several social reforms, including an employer's liability law for work done on government jobs and a mandatory 8-hour day in federal employment. The Taft administration ran into trouble, however, because of Taft's limitations as a political leader and the burgeoning progressive movement that threatened to fracture the Republican party. As the rift widened between the eastern conservatives and the midwestern progressives (sometimes called insurgents), Taft proved unable to mediate differences and find compromise solutions. Conservative by nature he drifted ever closer to the old guard.

Taft's troubles began with tariff reform. He called Congress into special session in 1909 and urged a reduction in duties. In the ensuing Senate battle, the House increased rates on manufactured goods, thus favoring the industrial Northeast and angering midwestern progressives. Taft's clumsy intervention helped to reduce tariff levels once again, but hardly to the satisfaction of the progressives. Taft signed into law the Payne-Aldrich Tariff, still deemed a protectionist measure.

Taft clashed with the progressives again when he seemed to support their rebellion against Speaker of the House Joseph Gurney Cannon but then abandoned them. He and the insurgents then wound up differing on details on railroad legislation. Most important, they came to loggerheads on conservation policy. Chief Forester Gifford Pinchot, a conservationist in the Roosevelt camp, accused Secretary of the Interior Richard A. Ballinger of having turned over rich coal deposits in Alaska to a syndicate. A congressional investigation exonerated Ballinger, and Taft fired Pinchot.

Taft's battles with the progressives gradually drew Roosevelt into open opposition to the administration. In early 1912, Roosevelt decided to challenge Taft for the Republican presidential nomination. Taft controlled the party machinery, however, and defeated his former friend in the Chicago national convention. Roosevelt's creation of the PROGRESSIVE PARTY (or Bull Moose party) divided the Republican vote and resulted in the election of Democrat Woodrow Wilson. Taft finished a poor third.

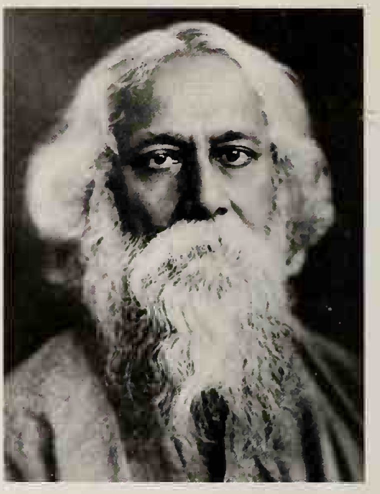
Later Life. After his stormy presidency Taft settled into a professorship at the Yale Law School and served as co-chair of the National War Labor Board during World War I. In 1921, President Warren Harding appointed him chief justice of the United States. Serious illness forced him to leave the bench in early 1930; he died Mar. 8, 1930.

Taft-Hartley Act see LABOR-MANAGEMENT RELATIONS ACT

Tagalog language see MALAYO-POLYNESIAN LANGUAGES

Taganrog [tuh-guhn-rawk'] The city of Taganrog is located in Rostov oblast in the Russian republic of the USSR. The city has a population of 291,000 (1989). Taganrog lies on the north shore of the Sea of Azov. Founded by Peter I in 1698 as a naval base, Taganrog developed under the tsars as a grain-shipping port and, after the 1890s, as a manufacturing center. During the Soviet period, Taganrog has been overshadowed by nearby Rostov-on-Don. The playwright Anton Chekhov was born in Taganrog.

Taglioni (family) [tah-lee-oh'-nee] The Taglionis were a family of notable dancers and choreographers who flourished in the 19th century. A native of Italy, **Filippo Taglioni**, b. Nov. 5, 1777, d. Feb. 11, 1871, performed and staged ballets in many of the dance capitals of the Continent, Scandinavia, and Russia. He was a key figure in shaping the style of 19th-century romantic ballet, in which a light, ethereal quality in the technique and an atmosphere of spirituality is contrasted with earthier or exotic folk material, epitomized in his *La Sylphide* (1832). The airiness and delicacy of the technique and the chaste mood of the style he formed were in part created in conjunction with the virtues (and faults) of his daughter, **Marie Taglioni**, b. Apr. 23, 1804, d. Apr. 22, 1884, who became the most renowned ballerina of the romantic period, rivaled only by Fanny ELSSLER. He turned her frail body, with its disproportionately long limbs, and her lack of overt sensual appeal into a personal idiom and created ballets to enhance it. The title role of *La Sylphide* became Marie Taglioni's signature. The image it created of an idealized, unearthly being persists in ballet even today. Taglioni was a potent legend in her own time, feted in international dance capitals in the 1830s and '40s. In the late 1850s she emerged from retirement to teach at the Paris Opéra.



Sir Rabindranath Tagore, a major Indian poet and playwright, was awarded the Nobel Prize for literature in 1913 for his poetic work Gitanjali (Song Offerings, *1910). Tagor wrote novels, stories, and songs as well as poems and plays dealing with philosophical and political subjects.*

Tagore, Sir Rabindranath [tuh-gohr', ruh-bin'-druh-naht] The Indian poet and author Rabindranath Tagore, b. Calcutta, May 7, 1861, d. Aug. 7, 1941, won the Nobel Prize for literature in 1913 for his most famous collection, *Song Offerings* (1910; Eng. trans., 1912). A prolific writer (3,000 poems, 2,000 songs, 8 novels, 40 volumes of essays and short stories, 50 plays), he drew inspiration both from his native Bengal and from English literary tradition. His major theme was humanity's search for God and truth.

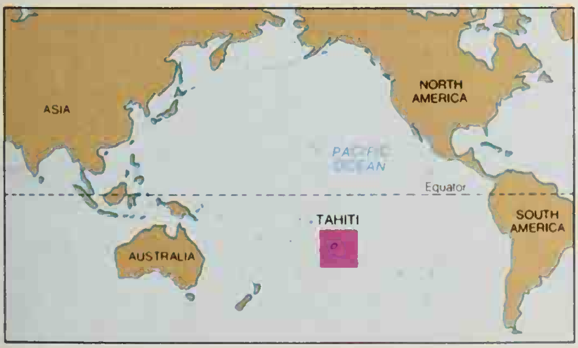
In 1890, Tagore published a volume of poetry, *Mānaśi* (The Mind's Embodiment), which foreshadowed the lyricism, eloquence, and grandeur of *Song Offerings* and *A Flight of Swans* (1914; Eng. trans., 1955). His profound symbolism, abetted by the free-flowing nature of his verse, create a universe of haunting beauty. Tagore's novels, particularly *Gora* (1910; Eng. trans., 1924), and short stories have strong underlying philosophical themes. The plays—notably *Sacrifice* (1890; Eng. trans., 1917), *The King of the Dark Chamber* (1910; Eng. trans., 1914), *Chitra* (1892; Eng. trans., 1913), and *Post Office* (1912; Eng. trans., 1914)—although allegorical and political, remain rich in characterization, sentiment, and spectacle. Tagore was also an accomplished composer, musician, and singer, as well as a painter and actor. He wrote a number of experimental dance dramas, the best of which, *Shyama* (1939), deals with social and religious issues.

Tagus River [tay'-guhs] The Tagus River, 1,000 km (625 mi) in length and with a drainage basin of 86,600 km^2 (33,400 mi^2), is the longest river on the Iberian Peninsula. Rising at an elevation of 1,600 m (5,250 ft) in the Sierra de Albarracín about 130 km (80 mi) east of Madrid, the Tagus flows southwest past Toledo through mountainous Spanish terrain, forms the boundary between Spain and Portugal for about 50 km (30 mi), then enters Portugal, flowing west to Abrantes and finally southwest past Santarém to its estuary, Lisbon Bay, which in turn is linked to the Atlantic Ocean by a 13-km (8-mi) channel. In the vicinity of Santarém, annual spring floods deposit a fertile silt. The river's 59 tributaries include the Jamara, Tajuña, Alberche, Alagón, Tiétar, Guadiela, and Zêzere. The Tagus does not allow commercial navigation beyond Santarém.

Taha Husayn [tah'-hah hoo-syn'] A dominant personality in politics, education, and literature in modern Egypt, Taha Husayn, b. Nov. 14, 1889, d. Oct. 28, 1973, was, though blind from youth, a distinguished writer and scholar. Because of his outspoken views on social and cultural matters, his career was rarely free of controversy. A prolific writer, he is best known for his autobiography (1929–32, trans. as *An Egyptian Childhood*, 1932, and *The Stream of Days*, 1943) and literary criticism, although he wrote a number of novels.

Tahiti Tahiti, the largest and most important of the Windward group of the Society Islands, lies in the central South Pacific about 5,600 km (3,500 mi) east of Australia. Its capital is Papeete. The island, with an area of 1,041 km^2 (402 mi^2) and a population of 107,000 (1983 est.), constitutes part of the overseas territory of French Polynesia. Two volcanic cones, Orohena (2,237 m/7,339 ft) and Roniu (1,332 m/4,369 ft), connected by the Isthmus of Taravao, give Tahiti a rugged landscape dissected by short, swift streams. Thousands of tourists visit Tahiti every year. The island's exports include coconuts, sugarcane, vanilla, and coffee.

The first European to discover (1767) Tahiti, English navigator Samuel Wallis, was followed by James Cook (1769, 1773, 1777) and William Bligh (1786), commander of the HMS *Bounty*. English missionaries began to convert the indigenous Polynesians to Protestantism in 1797, but after Louis Antoine de Bougainville claimed the island for France (1768), French missionaries won most inhabitants over to Catholicism. France established a protectorate in 1843 and annexed Tahiti in 1880. Paul Gauguin painted Tahitian landscapes, and Robert Louis Stevenson wrote about the island.



Tahoe, Lake [tah'-hoh] Lake Tahoe, located on the border of California and Nevada at the eastern edge of the Sierra Nevada range, was named for the Washo Indian word meaning "lake." A freshwater body in a deep faulted trough, Lake Tahoe has an area of about 500 km^2 (195 mi^2). Although its surface is 1,900 m (6,200 ft) above sea level, the lake's great depth of 500 m (1,600 ft) prevents it from freezing. More than 30 mountain streams feed Lake Tahoe. The Truckee River drains the lake to the northwest into Pyramid Lake in Nevada and irrigates land around Carson City. Noted for the clarity of its waters and the beauty of its location, Lake Tahoe has become the focus of a popular year-round resort. The tourist towns of Chambers Lodge and Tahoe City are located on the lake's western shores.

Lake Tahoe was discovered in 1844 by the U.S. soldier-explorer John C. Frémont while he was conducting a government surveying assignment. Tahoe National Forest, near the lake, was the site of the 1960 Winter Olympic Games.

tahr [tawr] A goatlike mammal in the genus *Hemitragus*, family Bovidae, the tahr is found in mountain forests of India, Nepal, and Oman. Standing about 1 m (40 in) at the shoulder, tahrs are about 1 m long, weigh up to 100 kg (220 lb), and typically have short, flattened horns that curve backward. The brownish hair is often shaggy, and the male Himalayan tahr, *H. jemlahicus*, bears a capelike mane hanging to the knees. Herds roam in search of any plant matter.

The Himalayan tahr is native to mountainous areas in southern Asia from Kashmir to Sikkim. Related to the goat and the sheep, it often lives in groups of 30 to 40 animals.

tai chi chuan see MARTIAL ARTS

T'ai-yüan see Taiyuan

Taiga [ty'-guh] Ikeno Taiga, 1723–76, was a prolific painter of the Nanga school, a Japanese style derived from the Chinese school of landscape art. Taiga transformed techniques learned from Chinese painting manuals into animated, decorative landscapes notable for their wit and conceptual daring. Early in his career he did finger painting, a Chinese technique he learned from Yanagisawa Kien, a Nanga pioneer. He was also a skilled calligrapher.

taiga climate The taiga climate is a cold forest climate of subarctic latitudes in the Northern Hemisphere. Also known as the subarctic or boreal forest climate, it extends in a broad zone from western Alaska across Canada to Newfoundland in North America, and from northern Norway to the Kamchatka Peninsula.

Continental air masses and low levels of insolation dominate the climate, producing large annual ranges of temperature, widespread permafrost, and meager precipitation. Average July temperatures reach 10° C (50° F), while January averages are as low as –40° C (–40° F). An extreme minimum of –68° C (–90° F) has been recorded in Siberia, and –63° C (–81° F) in the Yukon Territory.

Annual precipitation varies from more than 1,000 mm (40 in) on the west coast of Norway, where the maximum falls in winter, to less than 200 mm (8 in) in northwestern Canada and eastern Siberia, which have summer maximums. A large proportion of winter precipitation falls as snow.

Taine, Hippolyte Adolphe [ten] The French historian and literary critic Hippolyte Adolphe Taine, b. Apr. 21, 1828, d. Mar. 5, 1893, was identified with POSITIVISM, an all-embracing philosophy that sought to apply the scientific method to such speculative fields as literary criticism, history, and religion. Taine first devoted himself to literature, writing several perceptive studies—of Jean de La Fontaine's fables, Livy, and a number of French philosophers. His mature work first appeared in 1863–64 in his four-volume *History of English Literature* (Eng. trans., 1871). Taine's controversial analysis of the history of his country, which traced France's weakness to the divisive effects of the French Revolution, was published in six volumes as *The Origins of Contemporary France* (1876–93; Eng. trans., 1876–94). In 1878, Taine was elected to the Académie Française.

Taipei (Taibei) [ty-pay'] Taipei is the capital, largest city, and educational, commercial, and industrial center of Taiwan. The city is situated on the east bank of the Tanshui River in northern Taiwan. Surrounded by mountains, it is located 24 km (15 mi) from the coast. The city of Chilung, a part of Taipei's metropolitan area, is Taipei's port. The metropolitan area covers 272 km^2 (105 mi^2) and has a population of 2,702,487 (1990 est.).

In the early 1980s two-fifths of the population were mainland-born Chinese who had migrated to Taiwan after the Communist takeover of China in 1949. Major manufactures include textiles and clothing, machinery, ships, transportation equipment, and handicraft items. The National Taiwan University (1928) is located there. The National Palace Museum houses an important collection of Chinese art.

Founded in the early 18th century, the city became an important center for overseas trade. In 1891 it was officially designated the capital of Taiwan. Under Japanese control from 1895 to 1945, Taipei was renamed Taihoku. The city suffered heavy Allied bombing during World War II. It became the capital of the Republic of China in 1949 and in 1967 gained provincial status.

Taiping Rebellion [ty-ping'] The Taiping Rebellion (1850–64), a radical Chinese revolution, cost about 20 million lives and permanently weakened the QING (Manchu) dynasty. Its leader, Hong Xichuan, who had come under Christian influence, experienced religious visions and vowed to overthrow the Qing. After sweeping through southeastern China, the rebels, ultimately one million strong, took Nanjing in 1853 and made it the capital of their Taiping (Great Peace) kingdom. This kingdom, although founded on ideals of radical reform (puritanical moral precepts, primitive communism through equal distribution of land, full equality for women, and economic modernization), was weakened by leadership rivalries. Regional armies led by Zeng Guofan and LI HONGZHANG and a Western-trained force led by Charles George GORDON gradually overcame the rebels, and Nanjing fell in 1864.

Taiwan [ty-wahn'] Taiwan, formerly also known as Formosa, is the main island of the Republic of China (Nationalist China). Located 185 km (115 mi) off the southeast coast of mainland China, it became the last refuge for the government of the Republic of China under CHIANG KAI-SHEK and the KUOMINTANG (Nationalist party) in 1949, when Communists took over mainland China and proclaimed the People's Republic of China. Both Nationalist and Communist China claim that Taiwan is a province of China and seek its reunification, on different terms, with the mainland. As presently constituted, the Republic of China includes the island of Taiwan, 15 nearby islands that are part of the Taiwan group, 64 small islands in the Pescadores (Penghu Islands), and the islands of QUEMOY and Ma-tsu near the mainland.

Land and Resources

Two-thirds of Taiwan is mountainous; only one-third is lowland suitable for agricultural and industrial uses. The mountains rise abruptly along the east coast, reaching elevations of more than 3,050 m (10,000 ft) at more than 60 peaks. Hsin-kao, the highest peak, rises to 3,997 m (13,113 ft).

The climate is of the subtropical monsoon type. In winter, cold, dry winds blow out from Siberia toward Taiwan. In summer, hot, moist winds reach the island from the south and bring heavy rain. Rainfall averages 2,590 mm (102 in) annually. Temperatures average 15° C (59° F) in winter and 30° C (86° F) in summer.

The natural resources of the island are limited. Forests cover about 55% of Taiwan but are mostly inaccessible. Principal minerals include small deposits of coal, petro-

AT A GLANCE

REPUBLIC OF CHINA (TAIWAN)

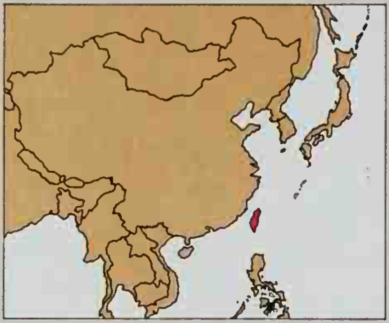
Land: Area: 36,002 km^2 (13,900 mi^2). Capital and largest city: Taipei (1990 est. pop., 2,702,487).

People: Population (1991 est.): 20,401,174. Density: 567 persons per km^2 (1,468 per mi^2). Distribution (1990 est.): 71% urban, 29% rural. Official language: Mandarin Chinese. Major religions: Daoism, Buddhism, Christianity.

Government: Type: republic. Legislature: National Assembly. Political subdivisions: 16 counties, 2 special municipalities, 5 municipalities.

Economy: GNP (1990): $161.75 billion; $7,997 per capita. Labor distribution (1990): commerce and services—24%; manufacturing—32%; agriculture and fishing—12%; construction—9%; government and public authorities—17%. Foreign trade (1990): imports—$55.9 billion; exports—$67.3 billion. Currency: 1 new Taiwan dollar = 100 cents.

Education and Health: Literacy (1990): 93% of adult population. Universities (1988): 16. Hospital beds (1988): 89,111. Physicians (1988): 20,590. Life expectancy (1990): women—77; men—72. Infant mortality (1990): 17 per 1,000 live births.



leum, and natural gas; salt produced from seawater; and gold, copper, sulfur, marble, and limestone.

People

About 84% of the population are native Taiwanese, descended from Chinese immigrants in the 18th and 19th centuries; they continue to speak the dialect of their ancestors from Fujian province. The second largest group are the "mainlanders" and their descendants (about 14%), who arrived on Taiwan in 1949 and have strongly promoted Mandarin as Taiwan's official language. Non-Chinese aborigines constitute a small minority (about 2%); they are descended from a people of Indonesian origin who lived on the islands prior to Chinese immigration and were subsequently pushed inland to the mountains by the new arrivals. Most Chinese are followers of Buddhism and Daoism and accept Confucianism as an ethical code. Animism is common among the aborigines, and Christianity is an important minority religion.

Taiwan's population has grown rapidly since 1956, but the proportion of adults and the elderly to the total population is increasing as a result of declining birth and death rates. Most people are concentrated in the western plains. TAIPEI and KAOHSIUNG are the principal cities.

Literacy is high, and ten years of basic education are free and compulsory for all children. About 60% continue their education in secondary and vocational schools, and higher education is encouraged. National Taiwan and National Taiwan Normal (both in Taipei) are the leading universities.

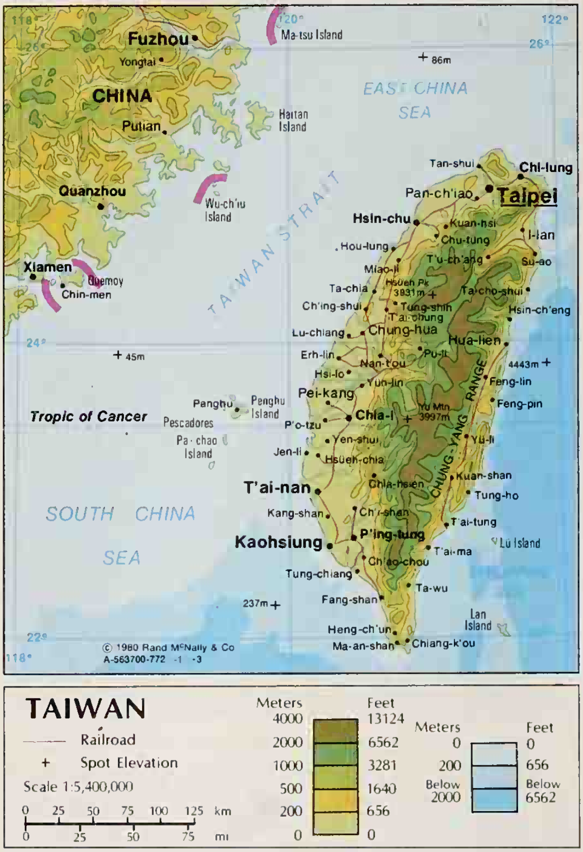
Taiwan considers itself the guardian of classical CHINESE ART AND ARCHITECTURE, CHINESE LITERATURE, and CHINESE MUSIC. The recently renovated National Palace Museum outside Taipei displays bronzes, paintings, and other treasures of China's artistic heritage. The traditional arts of Chinese opera and YUAN DRAMA are performed in the National Theater and Concert Hall in Taipei, opened in 1987.

Economic Activity

Agriculturally self-sufficient under the Chinese after the 17th century, Taiwan was developed (1895–1945) by the Japanese first as a rice-exporting colony and later as a supplier of sugarcane, bananas, pineapples, tea, and raw materials for Japan. Industrialization began after 1949, and by the early 1980s, Taiwan was a modern, industrial trading nation.

Most industries are labor-intensive and benefit from Taiwan's literate and technically competent labor force. The major products are textiles, clothing, electronics, footwear, toys, ships, and traditional handicrafts. Rice is the principal crop, and Taiwan is self-sufficient with regard to rice. The principal livestock are water buffalo, pigs, chickens, and ducks. Fishing is well developed.

Most railroads and highways run north-south through the populous western lowlands. Chi-lung (Keelong), at the northern tip of the island, and Kaohsiung, on the southwest coast, are the leading seaports. Taiwan's foreign trade increased more than tenfold between 1964 and 1974 and continued to expand rapidly thereafter. The



balance of trade is favorable, and additional revenues are derived from Chinese-owned shipping, remittances from overseas Chinese, and the tourist industry. The leading exports are electronics equipment, clothing, plastics, textiles, television and radio receivers, plywood, calculators, and toys. The major imports are crude petroleum, electronic components, foodstuffs, machinery, and iron and steel.

History and Government

Taiwan first became known to the West in the 16th century by its Portuguese name, *Formosa,* "beautiful." In the 17th century, Spaniards and Dutch briefly controlled parts of the island until the Dutch were driven out in 1661 by the pirate Koxinga, who made Taiwan a refuge after 1644 for supporters of China's deposed Ming dynasty. In 1683, Taiwan surrendered to the Qing (Manchu) dynasty and became part of China's Fujian province. In 1895, Taiwan was ceded to Japan after the first Sino-Japanese War and was developed as a Japanese colony. Reverting to Chinese sovereignty in 1945, it became a refuge for the Republic of China's Nationalist government in 1949 following the Communist takeover of the mainland.

From their base on Taiwan, the Nationalists under Chiang Kai-shek continued to claim legal sovereignty over all China. The United States supported Taiwan's claims and in 1954 signed a mutual security pact for the defense of Taiwan and the Pescadores. Chiang Kai-shek died in 1975. He was succeeded as president by his vice-president, Yen Chia-kan, but real power and leadership of the Kuomintang passed to Chiang's eldest son, CHIANG CHING-KUO. In 1971, Taiwan lost its seat in the United Nations to the People's Republic of China. It lost additional international support in 1978 because of the unilateral termination of the United States–Taiwan security pact, although the United States and Taiwan continued to maintain unofficial ties. Domestically, Taiwan's economic success contributed to mounting demands for political liberalization. Chiang Ching-kuo, who had been elected president and reelected in 1984, launched a policy of gradual democratic reform before his death in 1988.

Balloons are released in Presidential Square during Nation Day festivities in Taipei. Nation Day, also called Double Tenth Day because it is observed on each October 10, celebrates the revolution of 1911, which established the Chinese republic.

Martial law, in effect since 1949, was formally lifted on July 14, 1987, and bans on travel to and trade with the Chinese mainland were eased.

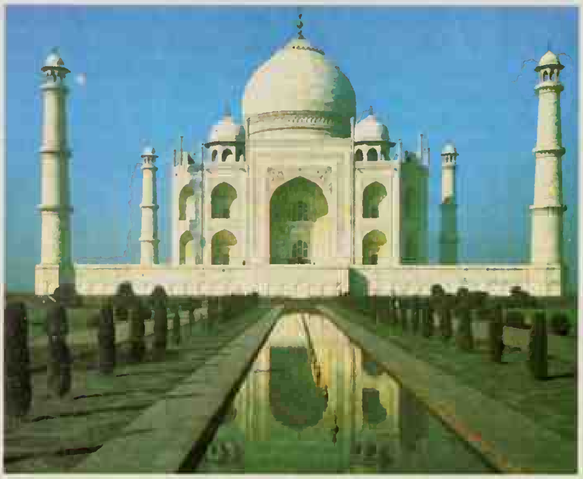
LEE TENG-HUI, who succeeded Chiang Ching-kuo as president and head of government (and later as head of the Kuomintang), was Taiwan's first native-born president. Elected in his own right in 1990, he continued the process of political liberalization. The state of emergency imposed in 1948, which had granted the president broad powers to override the constitution, was lifted in 1991. That same year, Lee signed a document technically ending four decades of "civil war" between Taiwan and the Chinese mainland. The Kuomintang captured 71% of the vote in December 1991 elections for a new national assembly, which was to revise the constitution.

Taiwan's constitution was adopted on the Chinese mainland in 1946. A president is head of state and government. Until the 1992 elections, members of the legislative and control yüans (councils) who had been elected on the mainland had held power indefinitely; in 1989, opposition parties had legally competed for the first time since 1949. Locally, Taiwan is also governed as a province of China. The provincial governor and the mayor of Taipei are appointed by the central government; the provincial assembly is elected.

Taiyuan (T'ai-yüan) [ty-yoo-ahn] Taiyuan, the capital of Shanxi Province in northern China, has a population of 2,010,000 (1989 est.). Located on the Fen River, a tributary of the Huang He, Taiyuan is surrounded by a rich coal- and iron-mining area. It is a great industrial city with a variety of heavy industries. Several institutions of higher learning are located there. The center of the ancient state of Zhao, Taiyuan was conquered by the Jin in the 3d century BC. It was ruled by the warlord Yan Xishan from 1912 until the Communist takeover in 1948.

Taj Mahal [tahzh muh-hahl'] The Taj Mahal, located on the Yamuna (Jumna) River in the city of Agra, India, is a monumental Islamic edifice built by Shah Jahan, Mogul emperor of India (r. 1628–58). Designed as an extraordinary representation of the throne of God in paradise, the structure also served as a mausoleum for the emperor's beloved consort Arjunand Banu Begum, who was also known by the title Taj Mahal ("crown of the palace"). It is widely acknowledged to be the greatest masterpiece of Indian Mogul architecture and one of the world's most beautiful buildings.

Work on the Taj Mahal was begun shortly after Arjunand's death (1631) and was completed in 1648. A domed building laid out in perfect symmetry along four axes, it represents the culmination of a tradition of secular mausoleums that had originated centuries earlier in Iran and Central Asia. The unique qualities of the Taj Mahal lie in the contrast between the white marble facade of the mausoleum and the red sandstone of the surrounding buildings, in the harmony of its parts, and in the rationally thought-out proportions between its fulls and voids. The interior of the mausoleum is illuminated through carved-marble screens set near the tops of the walls.



The Taj Mahal in India is one of the finest examples of Indo-Islamic architecture. The symmetry of the white marble mausoleum is accentuated by its reflection in the pool.

Tajik see TADZHIKISTAN

Tajikistan see TADZHIKISTAN

Takeshita [tah-keh-shee'-tah] Takeshita Noboru, b. Feb. 26, 1924, became head of Japan's ruling Liberal Democratic party in October 1987 and succeeded NAKASONE YASUHIRO as prime minister of Japan in November. First elected to parliament in 1958, Takeshita held cabinet posts under prime ministers SATO EISAKU, TANAKA KAKUEI, and Nakasone and was party general secretary before becoming premier. Tainted by an influence-peddling scandal that damaged his party, he left office in June 1989; his successor, Uno Sosuke, resigned in July.

Takli Makan Desert (Takla Makan) [tah'-kli mah-kahn'] The Takli Makan is a mostly uninhabited desert in Xinjiang province, northwestern China, bordered on the north, south, and west by the Tian Shan, Kunlun, and Pamir ranges. It covers an area of about 323,740 km^2 (125,000 mi^2). The desert is crossed by the TARIM RIVER, which disappears in the LOP NOR region to the east. The surface consists of shifting sand dunes with some exposed sandstone and clay. The Takli Makan is Asia's driest desert. Temperatures range from 38° C (100° F) in summer to –9° C (15° F) in winter. The sparse vegetation consists of tamarisk and grass. Indigenous animals include gazelles, wild boars, wolves, and foxes.

Talbot, William Henry Fox see PHOTOGRAPHY, HISTORY AND ART OF

talc Talc [$Mg_3Si_4O_{10}(OH)_2$] is a common, extremely soft, basic magnesium SILICATE MINERAL; compact aggregates are known as soapstone (steatite). Talc occurs as translucent, foliated or granular masses that vary in color from pale to dark green. Hardness is 1 (talc is softest on the standard scale of hardness), streak is white, luster is pearly, and specific gravity is 2.7 to 2.8. A product of low-grade metamorphism, it forms along with carbonate minerals by hydration of magnesium silicates such as the olivine or pyroxene in igneous rocks and by metamorphism of dolomite in sedimentary strata. Talc is also found in crystalline schists.

Talc has been used since ancient times for carved and engraved ornaments and utensils. Modern industrial applications include use in chemical-resistant and moderate-heat–resistant fixtures, in lubricants, in roofing materials, in ceramics, and as toilet powders, insecticide carriers, and paint and paper fillers.

Talc is a very soft, translucent, white to green basic magnesium silicate with a characteristic soapy feel. It is usually found in foliated or compact fine-grained masses. Talc's most familiar use is in talcum powder, but one of its most important applications is in the production of glazed wall tiles, porcelain, and other ceramics.

Tale of Genji, The see MURASAKI SHIKIBU

Tale of Two Cities, A Charles DICKENS's historical novel of London and Paris before and during the French Revolution, *A Tale of Two Cities* (1859) describes social and psychological crises more accurately than historical events. Dickens's vision of the Reign of Terror encompasses aristocratic exploitation and neglect of the poor, public bloodshed, and private vengeance. Sydney Carton, a worthless, pleasure-loving English barrister, redeems himself by a heroic gesture of self-sacrifice—he allows himself to be executed in place of a French aristocrat, Charles Darnay.

Talking Heads Talking Heads—whose albums include *Talking Heads:77* (1977), *Speaking in Tongues* (1983), and *Naked* (1988)—is an avant-garde U.S. rock band that fuses a distinctive musical style with band leader David Byrne's quirky, often enigmatic lyrics. Byrne and core band members Jerry Harrison, Tina Weymouth, and Chris Franz have expanded rock's range by drawing on polyrhythmic African melodies.

Byrne, b. Dumbarton, Scotland, May 14, 1942, has also directed films (*True Stories*—1986), designed album covers, and composed musical scores (for Twyla THARP's *The Catherine Wheel*, 1982, and Robert WILSON's *Civil Wars*, 1986). Byrne earned an Academy Award for his contributions to the score of Bernardo Bertolucci's film *The Last Emperor* (1987).

Tallahassee [tal-uh-has'-ee] Tallahassee, capital of Florida and seat of Leon County, is located in northern Florida, about 40 km (25 mi) from the Gulf of Mexico. The population is 124,773 (1990), and most workers are employed by the state and local governments. Tallahassee is the service center of northern Florida's cattle raising, lumbering, and cotton and commercial truck-farming region. The state capitol building, begun in 1826, has undergone several renovations, the most recent in the mid-1970s. The city is the seat of Florida Agricultural and Mechanical University (1887) and Florida State University (1857).

Hernando de Soto found an Indian village on the site in 1539, and the site was later a Spanish settlement. In 1824 it was selected as the state capital. During the Civil War, Tallahassee was the only Confederate state capital east of the Mississippi River to avoid capture.

Tallchief, Maria Maria Tallchief, b. Fairfax, Okla., Jan. 24, 1925, was the star ballerina during the early years (1947–65) of New York City Ballet and its forerunner, Ballet Society, and created many important parts in the works of George Balanchine, to whom she was married from 1946 to 1952. Tallchief was a brilliant technician. Her stage personality was mysterious and remote, yet she excelled in a wide variety of parts. From 1942 to 1947 she was a soloist with Ballet Russe de Monte Carlo, where she created important parts in Balanchine's *Danses Concertantes* and *Night Shadow*. As head of the Chicago City Ballet, she separated it from the city's Lyric Opera company in 1980.

Talleyrand-Périgord, Charles Maurice de [tahl-ay-rahn'-pay-ree-gohr'] Charles Maurice de Talleyrand-Périgord, b. Feb. 2, 1754, d. May 17, 1838, a French bishop, political leader, and diplomat, served in the top levels of most of the regimes that governed France between 1789 and 1848. Helped by the powerful archbishop of Reims, his uncle, he was named bishop of Autun in 1788. He sat in the First Estate of the States-General in 1789 and retained his seat when the States-General became the National Assembly. In October 1789 he proposed that the state take over the properties of the church; when this had been accomplished and the church reorganized as a virtual department of government, Talleyrand, in defiance of papal orders, consecrated the first new bishops of the constitutional church.

Talleyrand then obtained diplomatic appointments abroad, which enabled him to escape the Terror. In 1797 he became minister of foreign affairs under the Directory. He resigned in 1799 and helped prepare the coup d'état that made Napoléon Bonaparte (later Emperor NAPOLEON I) first consul. He was rewarded with the portfolio of foreign affairs. The emperor valued his services and rewarded him handsomely with property and titles. After 1805, however, Talleyrand began to regard Nepoleon's ambitions as dangerously excessive; he resigned in 1807 and started intriguing with the emperor's foreign enemies.

In 1814, Talleyrand played the leading role in bringing the Bourbon LOUIS XVIII to the French throne. Again his reward was the ministry of foreign affairs. In that position he represented France at the Congress of Vienna (see VIENNA, CONGRESS OF). He resigned in 1815 and retired for 14 years.

A close advisor of LOUIS PHILIPPE, duc d'Orléans, Talleyrand helped persuade the duke to accept the crown in 1830. Louis Philippe appointed him ambassador to London to win British recognition of the new Orléanist regime. He succeeded not only in that but also in negotiating a Franco-British settlement of the Belgian independence problem. Talleyrand retired from the London post in 1834, having served two Bourbon monarchies, the republic, the empire, and the July monarchy with cynical impartiality and effectiveness.

Tallinn [tal'-uhn] Tallinn is the capital of Estonia, in the USSR. Its population is 482,000 (1989). Tallinn's location on Tallinn Bay, an inlet of the Gulf of Finland, led to its prominence as a seaport and a manufacturing center specializing in the production of electric motors, cables, and other electrical goods. Fishing and fish processing are important.

The city is medieval in appearance and distinguished by Gothic architecture. The hilltop fortress of Toompea dates from the 13th–14th centuries. The city's name, which means "Danish castle" in Estonian, refers to its settlement by Danes in 1219. Tallinn was a major trade center of the Hanseatic League during the 13th and 14th centuries. It was annexed by Russia in the early 18th century and was then known as Revel.

Tallis, Thomas [tal'-is] Thomas Tallis, b. *c.*1505, d. Nov. 23, 1585, was an English organist and composer. He was organist of Dover Priory in 1532 but moved to London and then to Waltham Abbey, where he probably composed his early Latin motets. On the dissolution of the abbey, Tallis went to Canterbury for two years as a lay clerk at the cathedral, then to the Chapel Royal, where he remained until his death. It was there that he met, taught, and befriended William BYRD. Tallis mastered rich texture in the vein of Robert Fayrfax, the newer post-Reformation counterpoint exemplified in the motets and hymns in the *Cantiones sacrae* published jointly with Byrd in 1575, and the simpler, more homophonic style of his later anthems. As an unrivaled example of a contrapuntal tour de force, Tallis's motet *Spem in alium* (for eight choirs of five voices) stands alone. As a virtuoso organist and virginalist, Tallis left a small but remarkable collection of antiphons and hymn verses that also included two massive settings of the offertory *Felix namque.*

tallow tree [tal'-oh] Tallow trees are three unrelated species of trees whose fruits or seeds yield an oily or fatty substance that suggests tallow, or animal fat, and that has been used in the making of candles and soap; the trees are also used for lumber. The Chinese tallow tree, *Sapium sebiferum,* of the spurge family, Euphorbiaceae, grows to 12 m (40 ft) high. The fruits of the Sierra Leone butter, or tallow, tree, *Pentadesma butyracea,* of the garcinia family, Guttiferae, yield an edible oil also used in making margarine. The African tallow tree, *Detarium senegalense,* of the pea family, Leguminosae, may exceed 30 m (100 ft) in height. The term *tallow wood,* which refers to trees and lumber having an oily or greasy quality, is most commonly used for the Australian eucalyptus tree, *Eucalyptus microcorys,* of the myrtle family, Myrtaceae.

Talma, François Joseph [tahl-mah'] One of the greatest French actors, François Joseph Talma, b. Jan. 16, 1763, d. Oct. 19, 1826, was the shaping force of modern French theatrical technique. The first French actor to replace contemporary dress with period costuming, Talma substituted naturalness for exaggerated declamation in the speaking of theatrical verse. He made his debut (1787) in a Voltaire play and became famous in tragedies by Racine, Corneille, and Shakespeare.

Talmadge (family) The Talmadge family has been prominent in Georgia politics in the 20th century. **Eugene Talmadge**, b. Forsyth, Ga., Sept. 23, 1884, d. Dec. 21, 1946, served (1933–37, 1941–43) as Georgia's Democratic governor. A lawyer and farmer, he was Georgia's commissioner of agriculture (1927–33). As governor he advocated fiscally and racially conservative agrarian policies and opposed the New Deal. He died after winning (1946) the gubernatorial election for the fourth time. His son **Herman Talmadge**, b. McRae, Ga., Aug. 9, 1913, also served (1948–55) as governor of Georgia until he was elected (1956) Democratic U.S. senator from Georgia. He was reelected in 1962, 1968, and 1974. In 1979, Talmadge was officially denounced by the U.S. Senate for "reprehensible" official financial conduct. He lost his bid for reelection in 1980.

Talmud [tal'-mud] The Talmud (Hebrew for "teaching" or "study"), a vast compendium of Jewish law and lore, is a unique literary document—a sequel to the Hebrew Bible—and the basis of Jewish religious life. It consists of the MISHNAH and lengthy, rambling commentary called Gemara (Aramaic for "learning" or "tradition"). There are two Gemaras—the Palestinian Gemara, a product of the 3d and 4th centuries AD, and the Babylonian Gemara, completed about 499, with some later additions. Hence, there are two Talmuds: the Talmud Yerushalmi and the Talmud Babli. The latter, the Babylonian Talmud, remains for traditional Jews the final authority on the law. The Mishnah is predominantly in Hebrew, the Gemaras largely in Aramaic. In addition to exhaustive and subtle discussions of civil, criminal, domestic, and ritual law, the Talmuds contain materials called haggadah ("narration")—statements on faith and morals, explanations of Bible verses, parables, and historical and legendary narratives.

Talon, Jean [tah-lohn'] Jean Talon, b. *c.*1625, d. Nov. 24, 1694, was the first intendant (1665–68, 1670–72) of New France in Canada. As the effective ruler there, reporting directly to the French king, Talon promoted agricultural and commercial development, exploration of the interior, and immigration; under his administration the population almost doubled.

tamarack [tam'-uh-rak] Tamarack is a common name of the conifer *Larix laricina,* of the pine family, Pinaceae. Other common names are American or black larch and hackmatack. Unlike most conifers, this tree has deciduous leaves, 2 to 3 cm (0.8 to 1.2 in) long. Tamarack grows to 15 to 18 m (50 to 60 ft) tall and bears small, upright cones. The tree is native to the cooler parts of North America and favors moist to boggy soils. The wood makes a strong and durable lumber.

The tamarack, unlike most conifers, sheds its leaves, although not all at once. This tree grows in northern regions of North America.

tamarind [tam'-uh-rind] The tamarind is an evergreen tree, *Tamarindus indica,* believed to be native to eastern tropical Africa. Its name, a contraction of the Arabic *tamr hindi,* means "date of India." In India the tree is used for timber; its leaves furnish a dye, and its fruit pulp is used in chutneys and as a mild laxative. Tamarind-flavored beverages are popular in Italy and Latin America. The tamarind grows to a height of 24 m (80 ft). The pod that forms from the red to purplish, yellow-striped flowers is 8 to 20 cm (3 to 8 in) long. Within the pod is a brown, juicy, acid pulp and 1 to 12 seeds.

tamarisk [tam'-uh-risk] Tamarisks, or salt cedars, are 54 species of evergreen shrubs or small trees of the genus *Tamarix* of the family Tamaricaceae. Although they are native to Europe, Africa, and Asia, a few species have become naturalized to North America. They have small, scalelike leaves; long clusters of small white, pink, or rose flowers are borne on the ends of the branches or trunks, giving the trees an attractive feathery appearance. Tamarisks are useful ornamentals and windbreaks in desert and coastal regions because they can withstand drought and saline conditions.

Tamaulipas [tah-mow-lee'-pahs] Tamaulipas is a mountainous state in northeastern Mexico, with an area of 79,384 km^2 (30,650 mi^2) and a population of 2,244,208 (1990 est.). The most important resource is petroleum, discovered in the early 1900s: cotton, cereals, sugarcane, tobacco, and coffee are grown. CIUDAD VICTORIA is the capital, and TAMPICO is the major port. Once inhabited by Tamaulipan Indians, the area was conquered by the Spanish early in the 16th century but was not colonized until 1747. In 1846 it was occupied by U.S. forces during the Mexican War.

Tamayo, Rufino [tah-mah'-yoh, roo-fee'-noh] Rufino Tamayo, b. Aug. 26, 1899, d. June 24, 1991, was one of Mexico's leading painters and muralists. After studying (1917–21) at the Academy of San Carlos in Mexico City, he served as the head of ethnographic drawing at his native country's National Museum of Anthropology while pursuing his own art. He first rose to prominence in modernist art circles after moving (1936) to New York, and his European reputation was established during a 10-year (1954–64) sojourn in Paris. Unlike Diego RIVERA and David SIQUEIROS, he largely ignored social-purpose art in favor of exploring the aesthetic possibilities that he combined with elements taken from Mexico's folk heritage in paintings such as *Women of Tehuantepec* (1939; Albright-Knox Art Gallery, Buffalo, N.Y.).

tambourine A small, shallow drum with a single head, the tambourine has metallic "jingles" fitted into its rim. It is played by shaking, striking it with the hand or a stick, or vibrating its head with a moistened thumb. The tambourine is of ancient origin and almost universal distribution. It is used to provide a Spanish or gypsy flavor in concert music or opera. It is also used by some rock music groups.

Tamerlane see TIMUR

Tamil [tam'-ul] The Tamil are an ethnic population of southern India, speaking a DRAVIDIAN LANGUAGE. They are concentrated in the southern Indian state of Tamil Nadu, where they number more than 32 million, and in northern Sri Lanka, where they number nearly 3 million (1984 est.). Large emigrant communities also live in southern Sri Lanka, Malaysia, Africa, Mauritius, and the West Indies. Like other Indian peoples, the Tamil are divided into CASTES. Caste is said to be more strictly observed in Tamil Nadu than in other parts of India.

In general, the Tamil trace descent through the male line and favor the marriage of close kin. The traditional mainstay of their economy is irrigated rice cultivation. During the medieval period, Tamil literature was at its height, and some of the most famous Hindu temples in India are in Tamil Nadu. In Sri Lanka the minority Tamils dominated the civil service and various professions in the British colonial era. Tamil culture has experienced a resurgence in recent times in both India and Sri Lanka. The Tamils of Sri Lanka feel they have been systematically discriminated against by the Sinhalese majority since independence. In the 1980s a terrorist campaign by militant Sri Lankan Tamil separatists there led to outbreaks of communal violence.

Tamil Nadu [tam'-ul nah'-doo] Tamil Nadu (formerly Madras) is a state in southeast India located on the Coromandel coast of the Bay of Bengal. It covers an area of 130,000 km^2 (50,000 mi^2) and has a population of 48,408,077 (1981). Tamil Nadu is bounded by the Indian Ocean on the east and south. The states of Kerala, Karnataka, and Andhra Pradesh surround Tamil Nadu on the west, northwest, and north, respectively. The capital is MADRAS. The eastern part of the state is a low-lying plain, and the northern and western regions are hilly. Three-fourths of the population, which is predominantly Tamil, engage in agriculture. Cotton, including the distinctive dyed cloth called MADRAS, silk fabrics, processed foods, cars, and motorcycles are manufactured there.

The seat of the Chola empire from AD 850, Tamil Nadu was part of the Hindu kingdom of Vijayanagar (1336–1565). From 1639, when the British opened a trading post there, until 1947, when India gained independence, the area was almost continually under British control. The modern state was formed in 1956, and the name was changed from Madras in 1969.

Taming of the Shrew, The William SHAKESPEARE's energetic, farcical comedy *The Taming of the Shrew* is an exuberant exploration of the male fantasy, common in folklore, of taming a headstrong, stubborn, and high-spirited woman so that she will make a docile wife. Petruchio and Kate contend with each other with tremendous vitality, and Petruchio seems to enjoy great success in his program of reeducation. In modern interpretations, however, Kate's submissiveness is made to seem ironic; she has finally discovered the secret of how women can dominate their men. The taming action actually constitutes a play-within-the-play performed for the benefit of Christopher Sly, a drunken tinker.

Tammany Hall [tam'-uh-nee] A Democratic party organization in New York City, Tammany Hall frequently dominated city and even state politics in 19th- and 20th-century New York. Founded in 1789 and named for a legendary Delaware chief, it became a partisan club, supporting Thomas Jefferson's Democratic-Republican party in the early 1800s. With the establishment of universal white manhood suffrage in the 1820s and increased Irish immigration after 1830, it won support by helping immigrants find jobs and become citizens and by assisting the poor.

By mid-century, Tammany often controlled city and county politics in New York, organizing voters and electing its candidates so efficiently that its methods were called machine politics. Tammany was led by powerful political bosses, including William M. TWEED in the 1860s and early 1870s and Charles ("Silent Charlie") Murphy in the early 1900s. Tweed became notorious for looting the city treasury, while Murphy, on the other hand, sought respectability by endorsing working-class reform legislation and sponsoring outstanding young politicians, notably Robert F. WAGNER, Sr., and Alfred E. SMITH.

In the 1930s, Tammany was weakened by the election of antimachine candidate Fiorello LA GUARDIA as mayor and by the New Deal social-welfare programs that reduced the dependence of the poor on Tammany's services. Revived in the 1950s under Carmine G. De Sapio, the Tammany organization subsequently disappeared.

See also: BOSS, POLITICAL.

Tampa [tam'-puh] Tampa is a city in west central Florida, located on a peninsula across Tampa Bay from Saint Petersburg. The seat of Hillsborough County, Tampa has a population of 280,015 (1990), and the Tampa-St. Petersburg-Clearwater metropolitan area, 2,067,959. Tampa is Florida's leading industrial city, where plastics, food products, and cigars—made in the Latin quarter of Ybor City—are produced. Tampa is also a wholesale and retail distribution hub and service center. The city has an excellent harbor from which locally mined phosphates are exported. Tampa is the home of Busch Gardens theme park. Although Pánfilo de Narváez first saw Tampa Bay in 1528, the hostility of the local Indians was so intense that no permanent settlement was established until 1823, 4 years after the Florida territory became a U.S. possession. Growth was slow until a rail link joined the city with Jacksonville to the northeast in 1884, and Tampa became a popular tourist center.

Tampere [tahm'-pair-ay] Tampere, a city in Finland, lies in the southwestern part of the country, about 160 km (100 mi) northwest of Helsinki. It has a population of 171,608 (1990 est.). A major manufacturing hub and the textile center of Finland, Tampere also produces metals, heavy machinery, pulp, and paper. Noted for its lakes, gardens, and modern architecture, the city has educational institutions, museums, and a planetarium. Tampere was founded in 1779, and industrial growth began in 1821 when the Russian tsar Alexander I allowed tax-free imports.

Tampico [tahm-pee'-koh] The Mexican port of Tampico lies 10 km (6 mi) from the coast of the Gulf of Mexico in the southernmost part of Tamaulipas state. The population is 267,957 (1980). The center of a rich petroleum-producing area, both offshore and on land, Tampico has petroleum refineries and storage tanks, machine-repair shops, shipyards, clothing factories, and canneries. Exports include petroleum, minerals, cotton, and sugar. It is also a popular resort, with tourist facilities centered on Playa Miramar. The swamps and lagoons around the city are good wildfowl-hunting and fishing areas. Settled in 1823 on the site of a former Aztec village, Tampico became important after the discovery of petroleum there in 1911.

Tana, Lake [tah'-nah] Lake Tana, Ethiopia's largest lake, covers about 3,630 km^2 (1,400 mi^2) in the northwestern part of the country at an elevation of 1,850 m (6,000 ft). Fed by the Upper Nile and about 60 other streams, the lake is the source of the Blue Nile.

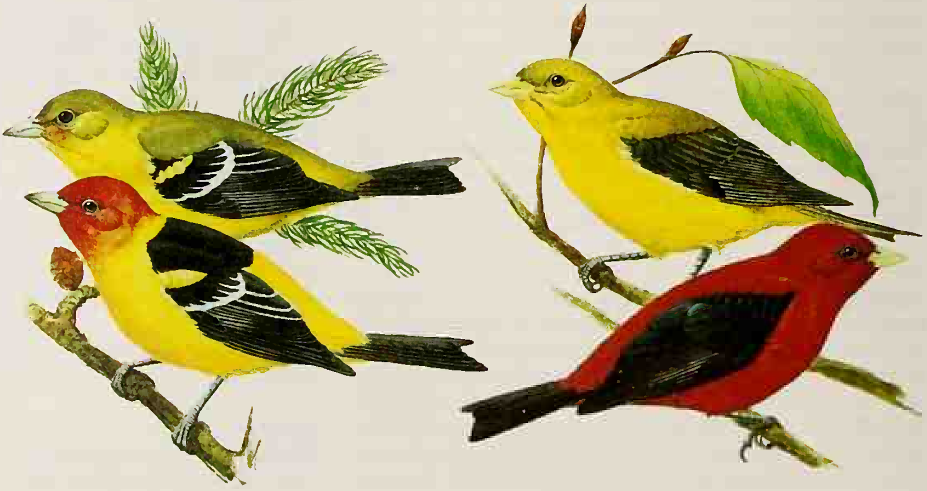
tanager [tan'-uh-jur] Tanagers, subfamily Thraupinae, family Emberizidae, comprise more than 220 species of typically brightly colored arboreal birds of the New World. Most species are tropical and subtropical; only four species that winter in Central and South America venture north of Mexico as summer visitors. Tanagers range from about 7.5 to 30 cm (3 to 12 in) in length and usually have conical bills, short necks, rounded wings, and short-to-medium tails; some species are crested. Most feed on insects and fruit, with some species destroying insects harmful to plants. Some tanagers nest in trees and others in shrubs or ground crevices. During the breeding season, the male scarlet tanager, *Piranga olivacea,* found in the eastern United States and southern Canada, is strikingly beautiful, with a crimson red body and jet-black wings.

Tanaka Giichi [tah'-nah-kah gee-ee'-chee] The Japanese general and statesman Tanaka Giichi, b. June 22, 1863, d. Sept. 28, 1929, was known as a mastermind of Japanese expansionism. Tanaka fought in the Russo-Japanese War (1904-05). Later, as minister of war (1918–21, 1923–24), he promoted both the Siberian expedition against Russia's Bolshevik regime and an aggressive China policy. He became head of the Seiyukai party in 1925 and served as prime minister from 1927 to 1929.

Tanaka Kakuei [tah-nah'-kah kah-koo'-ay] Tanaka Kakuei, b. May 4, 1918, was prime minister of Japan from 1972 to 1974, when scandal forced his resignation. In 1983, Tanaka was convicted of accepting bribes from the Lockheed Corporation while premier. Twice secretary general of the Liberal Democratic party (1965–66, 1968–71), Tanaka remains head of the party's largest faction and one of the most powerful politicians in Japan.

Tananarive see ANTANANARIVO

Taney, Roger B. [taw'-nee] Roger Brooke Taney, b. Calvert County, Md., Mar. 17, 1777, d. Oct. 12, 1864, was the fifth chief justice of the U.S. Supreme Court, succeeding (1836) John Marshall. Reversing the trend



The western tanager (left) *feeds in the treetops of coniferous forests in western North America. Both the male* (foreground) *and the female are recognized by their distinctive wing bars. The scarlet tanager* (right) *is commonly found in oak and pine forests in the east. The male* (foreground) *in breeding plumage is the only North American bird with a red body and black wings and tail.*

that Marshall had begun of creating strong federal controls in government, Taney urged greater local controls. A graduate (1795) of Dickinson College, he served (1799–1800) as a Federalist in the Maryland House of Delegates and in 1827 was appointed attorney general of Maryland.

In 1831, President Jackson made Taney U.S. attorney general and sought his help in opposing the Bank of the United States. Though he failed to gain Senate approval in 1833 as secretary of the Treasury and again in 1835 as an associate justice of the Supreme Court, Taney was confirmed a year later as chief justice because of changes in the Senate membership. In his most famous decision—Dred Scott v. Sandford (1857)—he ruled against congressional attempts to bar slavery from the territories and held that slaves or their free descendants were not citizens. In another controversial ruling (*Ex parte Merryman*, 1861), Taney declared President Lincoln's wartime suspension of habeas corpus unconstitutional.

Tang (T'ang) (dynasty) [tahng] One of the most glorious periods in the history of China was that of the Tang dynasty (618–906), at whose zenith the Chinese empire was the largest, wealthiest, and most populous on earth. **Li Yuan**, the first Tang emperor, came to power in 618 and abdicated in 626 in favor of his ambitious son, who reigned (627–49) as **Taizong**. This period marked the first great blossoming of the Tang era, as Chinese suzerainty was extended west into Afghanistan and Turkistan as well as south to Tibet. Taizong's successor, **Gaozong** (r. 649–83), brought Korea and Japan into tributary relationship to China. Further consolidation was carried out by the Empress **Wu** (r. 690–705), one of China's few female sovereigns.

A massive bureaucracy was recruited by a perfected and increasingly used examination system. The Tang government and the Tang code of laws, based on Confucian thought, became models for neighboring states. Foreigners were welcome; they introduced new ideas and technology as well as new religions, such as Zoroastrianism and Nestorian Christianity.

In this tolerant atmosphere the arts flourished, culminating in the second blossoming of the T'ang dynasty during the reign (712–56) of the emperor **Tang Xuanzong**. The painter Wu Daozi and China's two famous poets, Li Bo and Du Fu, were active at this time. A little later, Bo Ju'yi began writing poetry in a near vernacular style, and the art of short-story writing was soon thriving.

Under Tang Xuanzong, military commanders began to acquire independent authority. By the 9th century, Tang power was spent, and the dynasty ended in a welter of rebellions and civil strife.

This ink drawing, depicting a Chinese aristocrat and his attendant, dates from the early Tang dynasty. The vitality of the period was expressed in both the "calligraphic" style shown here and the developing court style of landscape painting.

Tang Xuanzong (T'ang Hsuan-tsung) [tahng shwahn-tsung] Tang Xuanzong, also known as Ming Huang (Enlightened or Lustrous Emperor), 685–762, 6th emperor (r. 712–56) of the Tang dynasty, brought Tang power and culture to their highest point. Successor to his father, Jui Zong (r. 684–90, 710–12), he strengthened the central administration and fought successfully against the Turks and Tibetans. In 755, however, a powerful military commander, An Lushan, began a revolt that forced Tang Xuanzong to abdicate in favor of Su Zong (r. 756–62).

Tanganyika see Tanzania

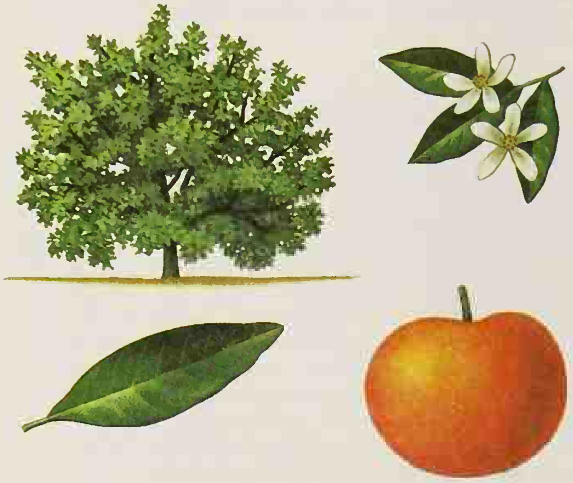
Tanganyika, Lake [tan-guh-nee'-kuh] Lake Tanganyika, in east central Africa in the Great Rift Valley, is the second largest lake in Africa and the second deepest lake in the world. About 680 km (420 mi) long and as much as 70 km (45 mi) wide, it covers 32,900 km^2 (12,700 mi^2). Depths reach 1,436 m (4,710 ft). An important waterway crossed by steamers, Lake Tanganyika is bounded by Tanzania in the east, Zaire in the west, Burundi in the northeast, and Zambia in the south. Its main port is Bujumbura, Burundi. The first Europeans to reach Lake Tanganyika were John Hanning Speke and Richard Burton in 1858. In 1871 the lake was explored by David Livingstone.

Tange, Kenzo [tahng'-ee, kayn'-zoh] The Japanese architect Kenzo Tange, b. Imabari, Shikoku, Japan, Sept. 4, 1913, has designed structures throughout Japan and in many other countries of the world. For his earliest design concepts he turned to the European influence of Le Corbusier: the facade of the Imabari Municipal Office Building (1957–58), for example, reflects aspects of Le Corbusier's work at Chandigarh, India. Other elements of Tange's work are more traditionally Japanese. The Kagawa Prefectural Offices at Takamatsu (1955–58) employs interlocking concrete beams arranged much like the lumber planks in Japanese temple shrines. A similar concern for the expressive use of structure may be seen in the Olympic Sports Stadia in Tokyo (1961–64), where cable roofs are suspended from concrete masts. After 1960, Tange's interests turned to urban planning. His concept for housing to be built over the Bay of Tokyo (1960) proposed temple-shaped clusters of apartments connected by vertebrae containing transportation links.

tangent In any right-angled triangle, the tangent of the acute angle θ is a ratio: the length of the side opposite θ divided by the length of the adjacent side. The tangent of θ is usually abbreviated as tan θ. *Tangent* is also often used as an adjective meaning "to touch." A tangent line is a line that touches a curve at a single point. A tangent plane is a plane that touches a surface at a single point. Tangent circles are those which have a common point; they touch each other at this point and only at this point. In Cartesian coordinates, tan θ is the ratio of the y-coordinate divided by the x-coordinate of point $P(x,y)$ on the circumference of a unit circle, where the radius makes an angle θ with the positive x-axis (see TRIGONOMETRY). In this case, tan θ is a circular function that repeats every 180°.

tangerine The tangerine, or mandarin, *Citrus reticulata*, of the citrus family, is an orangelike fruit that, with its hybrids, ranks after the orange in worldwide economic importance among CITRUS FRUITS. Native to China, one variety, Dancy, was introduced into Europe via the Moroccan seaport of Tangier and was originally called the Tangiers orange. The names *tangerine* and *mandarin* are now used interchangeably.

Most tangerine trees and their flowers and fruits resemble those of the orange, although tangerines are generally smaller. Tangerine peel adheres loosely to the flesh, and the segments are easy to separate. Although juice content and composition are similar, many tangerine varieties have a more deeply colored rind and flesh color than the orange.


The tangerine is produced from a small, thorny tree that bears simple leaves and orangelike blossoms.

About a third of the world production of tangerines is grown in Japan, which exports a variety called the Satsuma mandarin. Spain, Italy, the United States, and Brazil are also major producers. Most of the U.S. crop is grown in Florida.

Of the many tangerine hybrids, the most widely produced are the tangelos, hybrids of tangerines and grapefruits, and hybrids with the sweet orange.

Tangier [tan-jeer'] Tangier is a seaport city on the northern coast of Morocco at the western end of the Strait of Gibraltar (see GIBRALTAR, STRAIT OF) about 30 km (18 mi) south of Spain. With a population of 312,227 (1982), it is the oldest continuously occupied city in Morocco and the principal port for passenger service. Tourism is the main industry. Roads and railroads connect Tangier with other tourist centers. Construction, textile industries and fishing supplement the economy. The old section of Tangier, surrounded by 15th-century fortifications, includes the former royal palace; the Grand Socco, or main market area; and the 17th-century Great Mosque.

Settled as early as the 15th century BC by the Phoenicians, the city was occupied by the Carthaginians and, from 82 BC, by the Romans, who called it Tingis. Captured by the Arabs AD *c.*705, the city was ruled by Islamic dynasties until 1471, when the Portuguese seized control. After a brief period of English rule (1662–84), the city was restored to Morocco. Tangier acquired its international character in the 18th century when foreign ambassadors to the Moroccan court were housed there. Because of the strategic location at the entrance to the Mediterranean, the city and the surrounding area were given international status in 1923 and were governed by an international commission until 1956.

Tanglewood Festival The Berkshire Music Festival, since 1984 officially called the Tanglewood Festival, is held each summer at the Tanglewood estate, overlooking Lake Mah-Kee-Nac (also known as Stockbridge Bowl) in Lenox, Berkshire County, Mass. The BOSTON SYMPHONY ORCHESTRA first performed there in 1937 under the leadership of famed conductor Serge Koussevitzky. Tanglewood then became the permanent summer home of the orchestra and the location of its academy for advanced training in music, the Berkshire (now Tanglewood) Music Center. In 1938 a music shed was erected; designed by Eero Saarinen and Joseph Franz, the shed provides seating for more than 5,000 patrons, with additional seating for many thousands more on the spacious lawns of the estate.

The festival runs from late June through late August each year and comprises weekend performances by the Boston Symphony, recitals by renowned soloists, and concerts of all kinds by members of the music center. Both the festival and the music center are activities of the Boston Symphony Orchestra.

tango A dance that evolved in Buenos Aires at the end of the 19th century, the tango is probably derived from the *milonga*, a lively, suggestive Argentinian dance, and the *habanera* of Cuba and the West Indies. By the 1920s it had become a popular ballroom dance in Europe and the United States, and had been transformed into a flowing, elegant series of steps accompanied by somewhat melancholy music.

Tanguy, Yves [tahn-gee', eev] Yves Tanguy, b. Paris, Jan. 5, 1900, d. Jan. 15, 1955, a self-taught painter, became a leading figure in the French surrealist movement of the 1920s (see SURREALISM, art). Moved by the works of Giorgio de Chirico and stimulated by his friendship with the surrealist writer Jacques Prévert, he took up painting in 1923, joining André Breton's newly formed surrealist group in 1925. He then began to develop his peculiar vision of airless landscapes, such as *Indefinite Divisibility* (1942; Albright-Knox Art Gallery, Buffalo, N.Y.), in which strange, biomorphic objects hover in a strong, cold light. This dreamlike subject matter inspired most of his later work. Tanguy moved to the United States in 1939.

Tanis [tay'-nis] Tanis, a city of ancient Egypt on the Nile's eastern delta, situated at present-day San al-Hajar al-Qibliyah, was a major seaport and the capital of Egypt under the kings of the 21st dynasty; since it stood near the border with Asia, it was also significant militarily. Under other dynasties it was the capital of a province. The city remained important until the flooding of Lake Tanis (now Lake Manzala) led to its gradual abandonment during the 4th century AD. In 1866 the German Egyptologist Karl Lepsius discovered at Tanis an inscription known as the Decree of Canopus. Like the ROSETTA STONE, it was written in hieroglyphics as well as two other scripts, including Greek. Temples and statuary as well as a necropolis were also found.

Tanizaki Junichiro [tah-nee'-zah-kee jun-ee'-chee-roh] The Japanese novelist Tanizaki Junichiro, b. July 24, 1886, d. July 30, 1965, was a versatile writer who employed a wealth of narrative techniques. His novels brilliantly probe the psychology of dependence and domination between the sexes and celebrate the eternal, ever-elusive image of feminine perfection and the complementary figure of the adolescent male. In such novels as *Some Prefer Nettles* (1929; Eng. trans., 1965) and *The Diary of a Mad Old Man* (1962; Eng. trans., 1965) Tanizaki draws exquisite portraits of traditional Japanese culture and conveys an infectious zest for life.

tank, military see ARMORED VEHICLE

The S.S. Manhattan, *an ice-breaking tanker, became the first merchant ship successfully to navigate (1969) the Northwest Passage, demonstrating the route's feasibility for transporting petroleum.*

tanker A tanker is a ship designed to carry large volumes of oil or other liquid cargo. Basically, a tanker is a hollow shell in which one or more enormous oil tanks have been installed, each running the length of the ship.

The four basic types of tanker are oil tankers, chemical carriers, liquefied-gas carriers, and OBO (ore/bulk/oil) tankers. The first oil tanker was built in 1886 in Germany and had a capacity of 300 deadweight tons (1 dwt = 2,240 lb). Cargo capacity increased to 12,000 dwt in the 1920s, to 16,000 dwt by 1939, and to 27,000 dwt in 1947. By the 1970s a few new vessels could hold more than 300,000 dwt. The largest tankers today—the ultra large crude carriers (ULCC)—have capacities up to 500,000 dwt. Oil tankers have caused serious pollution problems, some because of accidents at sea (see OIL SPILLS), many because of the tanker's habitual method of cleaning their tanks—by flushing residual oil directly into the ocean.

The chemical-carrier division carries various types of chemicals for international distribution. The average chemical tanker capacity exceeds 20,000 dwt. The OBO tanker is a multipurpose bulk carrier designed for shipment of oil, bulk grain, fertilizers, or ores, with an average cargo capacity exceeding 200,000 dwt.

The volume of natural gas can be reduced substantially when the gas is liquefied: from 17.56 m^3 (620 ft^3) to 0.028 m^3 (1 ft^3); thus, liquefied natural gas (LNG) can be economically transported and stored (see PETROLEUM INDUSTRY).

Since the early 1980s, as oil sales have slowed, many oil tankers have been retired. LNG and chemical-carrier tanker fleets, on the other hand, continue to expand as the demand for the products they carry grows.

Tanner, Henry An African-American painter of genre and religious subjects, Henry Ossawa Tanner, b. Pittsburgh, Pa., June 21, 1859, d. May 26, 1937, spent most of his life in Europe. Having studied under Thomas

The Banjo Lesson *(c.1893), by the American artist Henry Tanner, is typical of the sensitive, naturalistic genre scenes for which he is best known. (Hampton Institute, Hampton, Va.)*

Eakins at the Pennsylvania Academy of Fine Arts, Tanner emigrated to Paris in 1891, partly to escape racial prejudice. Among his most moving genre pieces is *The Banjo Lesson* (*c.*1893; Hampton Institute, Hampton, Va.), showing an old black man teaching a boy to play. Tanner made two trips to Palestine to research his scenes from the Old and New Testaments. These, sometimes set at night or in murky interiors, are dramatic and deeply felt.

Tannhäuser [tahn'-hoy-zur] Tannhäuser was a 13th-century German lyric poet and minnesinger (see MINSTRELS, MINNESINGERS, AND TROUBADOURS) whose adventures became legendary and inspired many ballads and other poems. His extant lyrics suggest that he had been in the service of many noble patrons and that he probably participated in one of the Crusades. In legend he is associated with the Venusberg story in which, after tearing himself away from a life of pleasure, he makes a pilgrimage to Rome for the pope's absolution for his sins. He is told that his sins will not be forgiven until his staff sprouts leaves.

tanning see LEATHER AND HIDES

tansy [tan'-zee] Tansy is the common name for about 50 species of annual or perennial herbs of the genus *Tanacetum*, family Compositae. Common tansy, *T. vulgare*, has a pungent odor and aromatic juice, which is used as a flavoring but can be toxic in high doses. The dried leaves once were used as a medicine.

tantalum [tan'-tuh-luhm] Tantalum is a chemical element, a member of the third transition series of metals and of Group VB of the PERIODIC TABLE. Its symbol is Ta, its atomic number is 73, and its atomic weight is 180.9479. First discovered in 1802 by Gustav Ekeberg, it was confused with niobium until Heinrich Rose showed (1844) that niobic and tantalic acids were different.

The pure metal is gray, dense, hard, and malleable—it can readily be drawn into fine wires. Tantalum is extremely resistant to chemical attack and has a high melting point (2,996° C). Most tantalum is used to make electrolytic capacitors and vacuum furnace parts, and it also replaces platinum in chemical, surgical, and dental apparatuses and instruments.

Tantalus [tan'-tuh-luhs] In Greek mythology Tantalus was a son of Zeus and father of PELOPS and Niobe. He was admitted to the company of the gods and permitted to become immortal by eating their food. Depending on the story, Tantalus either stole ambrosia and nectar from the gods' table and fed the sacred food to mortals, or divulged divine secrets, or served his murdered son, Pelops, to the gods to test their omniscience. As punishment, he was condemned to stand eternally in water that receded when he tried to drink and to see beautiful boughs of fruit that bent just beyond his reach when he tried to eat. A great stone, hanging over his head, continuously threatened him. The word *tantalize* is derived from his name.

Tantra [tuhn'-truh] The term *Tantra* refers to a pan-Indian religious movement (also called Tantrism) that arose in about the 6th century AD within both BUDDHISM and HINDUISM and to the texts (either Buddhist or Hindu) setting forth its practices and beliefs. The main emphasis of Tantrism is on the development of the devotee's dormant psychophysical powers by means of special meditations and ritual techniques. These are essentially esoteric and must be passed on personally from master to initiate. Stressing the coordination of body, speech, and mind, they include the use of symbolic gestures (mudras); the uttering of potent formulas (MANTRAS); the entering (through meditation) of sacred diagrams (MANDALAS) and yantras; the meditator's creative visualization of and identification with specific divine forms; and the physical, iconographic, or mental use of sexual forces and symbols. (See also YOGA.) Although the particulars of practice vary between the Buddhist and Hindu Tantras and within each of these traditions from one text or lineage to another, they all stress the realization, within the body, of the union of polar opposites, whether these be conceived of as devotee and goddess, the masculine principle (Shiva) and the feminine (Shakti), reason and compassion, or samsara and nirvana. Tantrism is traditionally practiced in Tibet, Nepal, Bhutan, and other countries where Tibetan Buddhism is followed, as well as in India.

Tanzania [tan-zuh-nee'-uh] The United Republic of Tanzania is located in East Africa. Formed by a merger of the independent states of Tanganyika and the island of Zanzibar in April 1964, it is bordered by Mozambique and Malawi to the south; Zambia, Zaire, Burundi, and Rwanda to the west; Uganda and Kenya to the north; and the Indian Ocean to the east.

Land and Resources

Most of mainland Tanzania occupies a gently undulating plateau that averages above 1,050 m (3,500 ft) in elevation. The narrow coastal plain is backed by the edge of the plateau. A number of small mountain ranges and isolated volcanoes cap the plateau. Mount Kilimanjaro, the highest peak in Africa, rises to 5,895 m (19,340 ft) along the Kenyan border. Lake Victoria (see Victoria, Lake) is located in the northwest. Lake Tanganyika occupies the bottom of the East African Rift Valley along the western border. Lake Nyasa (or Lake Malawi), also part of the rift system, is in the south.

Zanzibar, separated from the mainland by a 35-km-wide (22-mi) channel, has an area of 1,658 km^2 (640 mi^2). Pemba, another island, is located 48 km (30 mi) northwest of Zanzibar and covers 984 km^2 (380 mi^2).

Because of Tanzania's tropical location temperature is largely a function of elevation. Greater rainfall (more than 1,420 mm/56 in) occurs in mountainous areas, whereas the central part of the country receives less than 610 mm (24 in). Average annual temperatures vary from 20° C (68° F) in the highlands to 32° C (90° F) on the coast.

The Rufiji River, draining into the Indian Ocean, is the principal stream. Forests are found only in the uplands, although woodlands composed of shorter trees and a less-closed canopy cover most of the country. As rainfall diminishes, grasslands become dominant. Animals range from antelope to zebra, from dik-dik to elephant. Mineral deposits are widely scattered, but none are of major economic significance. Most important are the diamonds from Shinyanga. Arable land covers 60% of the country.

People

Africans constitute about 99% of the population and are divided among approximately 120 ethnic groups. Most of these groups are small. The largest ethnic group, the Sukuma, constitute only 12.4% of the total. The country's people speak languages belonging to four distinct groups or families: the Bantu, accounting for about 95% of the total; Southern Cushitic; Nilotic; and Khoisan. Swahili is the official language (see African languages).

Tanzania is predominantly rural. The capital and largest city is Dar es Salaam. Dodoma, a new capital city being built in central Tanzania, has a population of 100,000 (1984 est.).

The country is justly proud of its achievements in edu-

AT A GLANCE

UNITED REPUBLIC OF TANZANIA

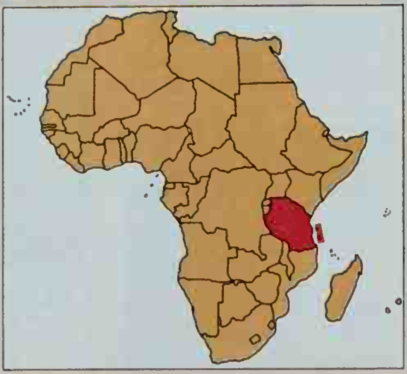
Land: Area: 945,087 km^2 (364,900 mi^2). Capital and largest city: Dar es Salaam (1988 est. pop., 1,360,850).

People: Population (1990 est.): 25,970,843. Density: 27.5 persons per km^2 (71.2 per mi^2). Distribution (1987 est.): 18% urban, 82% rural. Official language: Swahili. Major religions: traditional religions, Islam, Roman Catholicism, Protestantism.

Government: Type: one-party state. Legislature: National Assembly. Political subdivisions: 25 regions.

Economy: GNP (1989): $3.08 billion; $120 per capita. Labor distribution (1985): agriculture—83%; industry, commerce, other—17%. Foreign trade (1989): imports—$1.3 billion; exports—$394 million. Currency: 1 Tanzania shilling = 100 cents.

Education and Health: Literacy (1987): 85% of adult population. Universities (1987): 1. Hospital beds (1984): 22,800. Physicians (1984): 1,065. Life expectancy (1990): women—54; men—49. Infant mortality (1990): 107 per 1,000 live births.



cation and health care. The literacy rate, only 15% at independence, became the highest in Africa, although the educational system deteriorated badly in the 1980s. Education is free and compulsory for children between the ages of 7 and 14. The University of Dar es Salaam was founded in 1961.

Economic Activity

The agricultural sector provides more than 80% of all export earnings, although only 15% of the land is cultivated. Coffee, tea, cotton, sisal, pyrethrum, tobacco, and cashew nuts are the chief commercial crops; cloves provide about 45% of Zanzibar's export income. Cassava and corn are the primary subsistence crops. Manufacturing is overwhelmingly for domestic consumption. Some diamonds, gold, phosphates, tin, coal, and iron ore are mined.

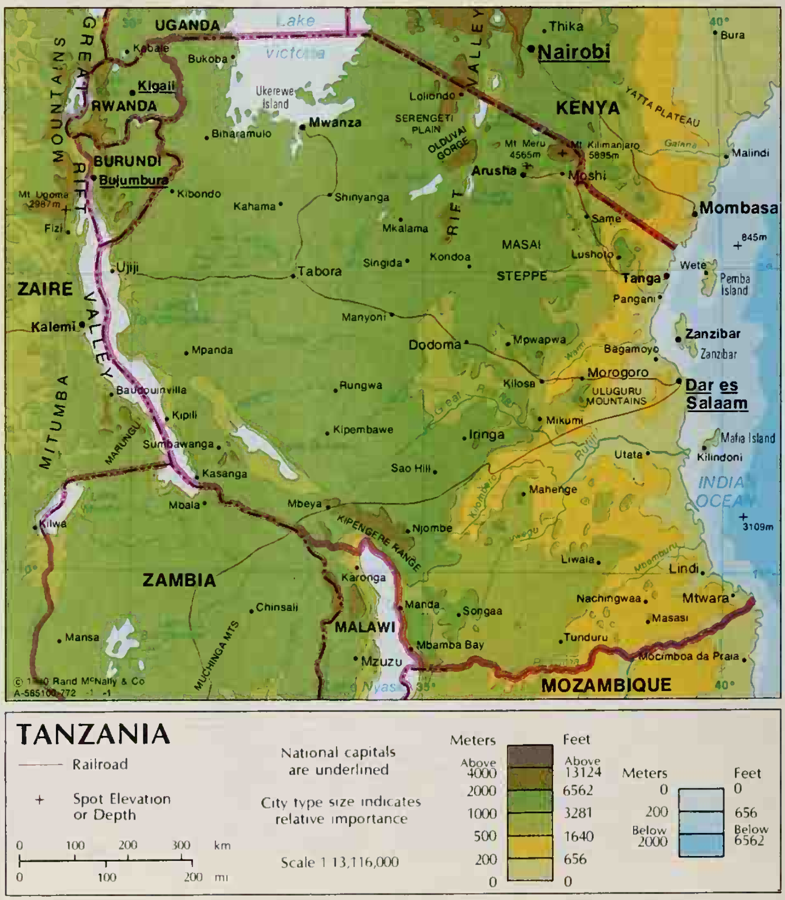
Large-scale socialization of the Tanzanian economy began with the Arusha Declaration in 1967. The keystone of this declaration was *ujamaa* (familyhood)—rural self-reliance and development based on collective activity. Banks, major industries, and trade were nationalized, and millions of peasants were resettled into agricultural cooperative villages. The economy grew steadily until 1977. From 1978 to 1984, however, per capita income declined 30%. In the 1980s the government began to modify its strict socialist economic policies. Attempts are also being made to develop tourism, discouraged after independence, as a source of much-needed foreign exchange.

Government

According to the constitution of 1977, executive power of the united republic is vested in the president, who is advised by a cabinet and a vice-president; if the president is from Tanganyika, the vice-president must be from Zanzibar, and vice versa. Most members of the national assembly are popularly elected. The sole legal political party is the Revolutionary party of Tanzania. Since 1965, Zanzibar has had control over internal affairs, with its own executive and legislature.

History

By the Late Stone Age, people lived (*c.*500 BC) at various places along the Tanzanian coast. Accounts of the coastal area in the 1st century AD describe a number of settlements where commerce took place. For the next millenni-



A herd of elephants forages for food along the grasslands, or savannas, of northeastern Tanzania near the Kenyan border. In the background lies Kilimanjaro, the tallest mountain of Africa at 5,895 m (19,340 ft).

Dar es Salaam, Tanzania's capital, largest city, and principal port on the Indian Ocean, was founded in 1862 by the sultan of Zanzibar. The city's initial growth dates from the colonial era, when Dar es Salaam prospered as the capital of German East Africa.

um Arab traders plied the coast, trading with Zanzibar and settlements on the Tanzanian mainland.

The principal settlement of Tanzania occurred by migrating waves of Bantu peoples. Probably originating about 2,000 years ago in eastern Nigeria, the proto-Bantu seem to have moved along the Congo River system into the southern portion of present-day Zaire. By the 10th century the areas around Lake Victoria and Lake Tanganyika had been settled. Bantu peoples continued to spread east and south in the 12th to the 15th centuries.

In 1498, Vasco da GAMA became the first European to visit the coast of Tanzania, and the Portuguese conducted trade along the coast until 1698, when they were expelled by Arabs from Oman. European missionaries and explorers such as David LIVINGSTONE entered the area in the 1850s. The Anglo-German Agreements (1886, 1900) divided spheres of influence along the present Kenya-Tanzania border, giving Germany control of the southern portion (today's Tanzania).

GERMAN EAST AFRICA was administered by the German East Africa Company. In 1891 the German government assumed control, and the region became a protectorate. Opposition to foreign rule mounted, and the quasi-religious Maji Maji rebellion lasted from 1905 to 1907. In 1920, as a result of the German defeat in World War I, the British took over German East Africa. In 1954, Julius NYERERE was one of the founders of the Tanganyika African National Union (TANU). The well-organized nationalist movement won independence for Tanganyika in 1961, and Nyerere became head of state. Zanzibar, which gained independence in 1963, joined Tanganyika in 1964; in 1965 the nation was renamed Tanzania.

Nyerere, who became one of Africa's most respected leaders, unified the country and expanded education and health care. He supported black liberation movements in Mozambique, Rhodesia (now Zimbabwe), and South Africa and sent troops to Uganda in 1979 to help depose dictator Idi AMIN DADA. The last Tanzanian forces withdrew from Uganda in 1981. Ideological differences led to the closing of the border between Tanzania and Kenya from 1977 to 1983. In 1984, mounting secessionist sentiments on Zanzibar forced the resignation of Zanzibar president Aboud Jumbe. His replacement, Ali Hassan Mwinyi, succeeded Nyerere when he retired as president of Tanzania in 1985 and won election in his own right in October 1990. Nyerere retained his post as party chairman until August 1990, when he stepped down to make way for political and economic reform.

T'ao Ch'ien see TAO YUANMING

Tao Te Ching see DAODE JING

Tao Yuanming (T'ao Yüan-ming) [tow yoo-ahn-ming] The greatest of Chinese nature poets, Tao Yuanming (courtesy name of Tao Qian), b. AD 365, d. 427, served as a magistrate in Pengze, but after a tenure of only 83 days he resigned and returned to his farm to lead a life of freedom and frugality. Tao Yuanming's poetical insight is rooted in the Daoist concept of oneness with nature. His poetry, which is marked by simplicity of diction and spontaneity of feeling, exercised an immense influence on later nature poets. He was also a skillful prose writer: *The Biography of Master Five Willows* is a charming self-portrait, and *The Peach-Blossom Fountain* describes a utopian world according to the Daoist ideal.

Taoism see DAOISM

Taormina [tah-ohr-mee'-nah] Taormina is a town with a population of 10,085 (1981) on the east coast of Sicily, about 50 km (30 mi) south of Messina. On a hill overlooking the Ionian Sea and within view of Mount ETNA, Taormina is a popular winter resort. Landmarks include a

Greek theater, Roman ruins, and the 14th-century Palazzo Corvaia. Founded in the 4th century BC by Dionysius the Elder of Syracuse, Taormina came under the Romans in 210 BC. It was seized by Arabs in the 10th century and fell to the Normans in 1079.

Taos [tows] Taos (1990 pop., 4,065), officially known as Don Fernando de Taos, is a town in north central New Mexico. Located at an altitude of about 2,135 m (7,000 ft), 90 km (55 mi) north of Santa Fe, it is the seat of Taos County. The ancient Pueblo Indian village of San Geronimo de Taos lies north of the town, and the Spanish farming center, Ranchos de Taos, lies to the south. Founded about 1615, Taos is one of the oldest white settlements in the United States. It became an important trade center on the Santa Fe Trail in the 19th century. Since the early 1900s the town has been a noted artists' colony.

tap dancing Except for the Indians' ritual dances, the first indigenous American art dance is tap dancing, whose roots lie in spirited Irish and English jigs and clog dances and in the rhythmic African improvisations that immigrants and free blacks combined spontaneously during the 1840s. Characterized by rapidly tapping toes and heels, usually in shoes fitted with metal tips, tap dancing evolved through both black and white minstrel shows, revues, vaudeville, musical comedy, and film, accumulating sophisticated new sounds for the feet. In 1900 the Floradora Sextet performed the first synchronized tap routine. The 50 girls of the first ZIEGFELD FOLLIES (1907) constituted the first tapping chorus line.

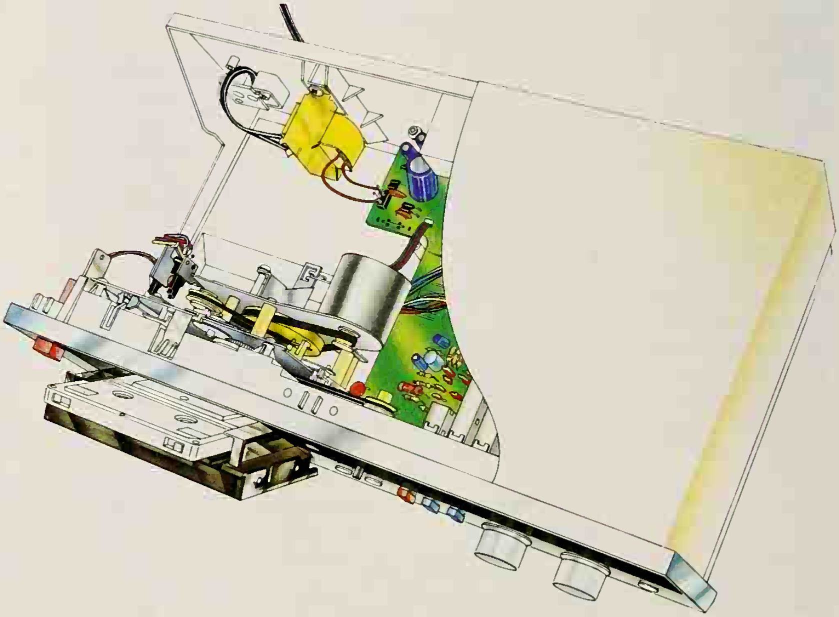
tape recording Tape recording is the recording and the replaying of sound or video on magnetic tape. Magnetic recording requires both a recording medium, a thin, flexible substance capable of carrying magnetic signals equivalent to the aural or video signals being recorded; and a device for recording and playback (see SOUND RECORDING AND REPRODUCTION).

Although the idea of magnetic recording had been suggested by several inventors in the late 19th century, the first operating equipment was built by the Danish engineer Valdemar Poulsen, who patented his machine in 1898. Poulsen used steel wires or thin steel ribbon for the recording medium, and his invention met with some commercial success before World War I. Germany patented a new kind of tape, a strip of paper coated with iron particles, in 1928; and in 1935, BASF, a branch of the German chemical company I. G. Farben, produced a particle-coated plastic tape, which was recorded by and played on the Magnetophon, a machine developed by AEG Telefunken.

Principles

In most of its forms the magnetic tape recorder employs the same basic principles. Aural or visual information is converted into an electrical signal, then mixed with a steady tone at a frequency higher than is required by the information itself. This tone, or AC bias, reduces distortion levels and allows for the recording of high-fidelity sound.

The combined signal is fed into the coil of a recording head, producing a fluctuating magnetic field that magnetizes the pigment (the magnetic particles) on the tape as the tape moves past the head. During playback the tape



On the front end of a cassette tape recorder, or tape deck, settings provide for tape bias change and noise reduction. Sound level is controlled by knobs and can be read off a display. The tape transport system is controlled by gears and a motor inside the deck, and by knobs on the front end (hidden here by the open cassette carrier) that specify record, playback, and so forth. Recording and playback are achieved as the tape moves over a record/playback head. A counter tracks elapsed time or the amount of tape used.

is passed over the playback head, and the tape's magnetic field induces a current in the head's coil. This current is then amplified and converted into a replication of the original information.

Tape Speed and Composition. In general, the higher the tape's transport speed, the higher the frequencies that can be recorded on it; also, the wider the individual recording tracks on the tape, the lower the noise level in the final output. A major variable in both respects, however, is the pigment used in the tape. In the 1950s, with the tapes then in use, minimum standards for quality home-music reproduction dictated a transport speed of 7½ inches per second (ips; 19 cm/sec) and two tracks (one monaural track in each direction of tape travel) on ¼-in (6.35-mm) tape. Today's cassettes, which at their best offer comparable fidelity, run at only 1⅞ ips (4.75 cm/sec) and contain four tracks (a stereo pair in each direction) on a tape barely ⅛ in (3.81 mm) wide. The good sound quality can be ascribed to improved tape formulation, as in chromium-dioxide and metal-particle tapes, and also to improvements in head design and electronics.

Noise-Reduction Systems. The most obvious drawback to the use of tape as a recording medium is "tape hiss"—an audible sound composed of high frequencies picked up at random in the recording process. Several systems have been developed to suppress tape hiss. The systems operate in essentially the same manner: before they are recorded, audio signals are passed through an encoder that compresses one or more frequency bands. During playback, a decoder expands the signals. This compression-expansion process, for all practical purposes, eliminates tape and FM hiss.

The Dolby system, the original noise-reduction process, is used today in two versions for consumer equipment: Dolby B compresses the upper treble range, suppressing noise by about 10 decibels (dBs). Dolby C adds the mid-range bands, reducing noise by some 20 dBs. A second popular system, DBX, affects all frequency bands simultaneously.

Types of Recorders

Reel-to-Reel Recorder. Originally, the standard tape format was the open-spool, or reel-to-reel, recorder, still used by professionals. Reel-to-reel tapes, however, have become increasingly elaborate. They may be as wide as 2 in (5.08 cm). The single track of the earlier monaural models has been replaced by 16, 24, or even more tracks, all of which can be recorded simultaneously.

Cassette Recorder. The compact cassette recorder, or tape deck, first introduced by Philips of the Netherlands in the early 1960s as a dictation machine, is now not only stereophonic but also contains the technology for reproducing amazingly fine sound. Most recorders have switches to accommodate different tape formulations; noise-reduction switches; and dials to indicate frequency levels during recording and playback. Tape cassettes offer 30, 45, or 60 minutes of recording on each tape side.

Digital Systems. Digital tape systems use magnetic pulses representing a binary encoding of signals—that is, after recording, all the magnetized particles on the tape will point in one of two directions. Analog systems, on the other hand, represent a sound according to the percentage of particles pointing in one or the other direction. Although analog systems are highly successful, they reproduce any noise or distortion that happens to occur in the recorded signal. Digital signals eliminate almost all noise and distortion. Digital audio tape (DAT) recorders, a Japanese introduction, may eventually replace analog recorders.

Videotape Recorders. Videotape recorders use a fixed recording head to record sound. The picture—which requires much higher recorded frequencies and therefore much higher head-to-tape speeds—is recorded by heads that are rotated in the direction opposite to and on a bias with that of the tape motion. This "helical scan" uses more available tape space, allowing for the storage of larger amounts of information (see VIDEO RECORDING).

tapestry The term *tapestry* refers to hand-woven, figured fabrics—usually of silk or wool—used for wall hangings and furniture upholstery. A tapestry is composed of a foundation weave, the warp, across which are passed the different colored threads of the weft, which forms a decorative pattern. The warp is covered completely by the weft threads, which are taken across the width of the warp first in one direction and then in the other within the boundaries of the different zones of color (see LOOM; WEAVING).

Technique

The colors and shapes of the pattern are indicated in a plan, or preliminary design, of the tapestry called the car-

Symbolic floral and mythological motifs decorate the tapestries of the Copts, the native Christian people of Egypt, whose art flourished from the 3d to the 12th century. (Musée Historique des Tissus, Lyon.)

toon (see CARTOON, art). Tapestries are woven on either high-warp or low-warp looms. The high-warp loom is vertical, with the warp threads stretched vertically between two rollers. The warp threads, usually linen, wool, or cotton, are separated by a rounded rod into two sets, back and front, of odd and even threads. All the even-numbered threads are placed in front of the separating rod and remain free, and the odd-numbered threads remain at the back, each encircled by a short loop, or heddle. By pulling on the heddles, which are attached to bars, with the left hand, the weaver brings the back threads through to the front; at the same time, the right hand threads the weft in between the two series of warp threads with a shuttle. The weft thread is passed first over the back set of warp threads (half weft) and then in the other direction over the front set, making a complete weft. On a low-warp loom the warp threads are stretched horizontally between the two rollers. The threads, again divided into an odd and even series, are now all equipped with heddles, which are arranged underneath the warp threads and controlled by treadles. By pressing down with the foot alternately on the treadles, the weaver can lower first one and then the other series of warp threads, allowing more rapid progress than high-warp weaving in which the weaver works with the hands alone.

History

Both systems were known and used in the earliest tapestries: a painting (*c.*3000 BC) found in the necropolis of Beni Hasan in Egypt shows a high-warp loom; the finest and most interesting of ancient tapestries were produced by this method in Egypt by the Copts beginning in the 3d century AD. The process of tapestry weaving was also known and practiced by the Hebrews, Greeks, Romans, Chinese, and Incas, among other ancient peoples.

Tapestries were not produced in Europe until about the 11th century. Thought to be the oldest surviving Western tapestry, the Cloth of Saint Gereon (originally in the Church of Saint Gereon in Cologne, Germany) is generally assumed to have been woven in Cologne in the early 11th century; it bears ornaments similar to those in illuminated manuscripts of the period. Germany, especially the region of Saxony, was a center for tapestries woven during the Romanesque period; examples are preserved in Halberstadt Cathedral.

By the 12th and 13th centuries, high- and low-warp weaving was practiced in France and Belgium, with centers of production established during the Gothic period in Paris and Arras in France and Tournai and Brussels in Belgium. The Parisian tapestry industry reached its height during the 14th century as a result of the patronage of Charles V of France and his brothers—Louis d'Anjou; Jean, duc de Berry; and Philip the Bold, duke of Burgundy. For Louis d'Anjou, the Parisian merchant and master weaver Nicolas Bataille supplied (1377–80) the seven immense *Apocalypse* tapestries (Musée des Tapisseries, Angers, France), the largest tapestry series ever woven, from cartoons by Hennequin de Bruges inspired

(Above) *A late-15th-century tapestry from Basel, Switzerland, portrays King Arthur and the emperor Charlemagne against a* milles-fleurs *("thousand flowers") background. (Historiches Museum, Basel.)*

"The Sense of Taste" (below) *is one of six celebrated tapestries from* The Lady and the Unicorn, *a set woven in the Loire Valley during the late 15th century. The figures are posed against a* milles-fleurs *background. (Musée de Cluny, Paris.)*

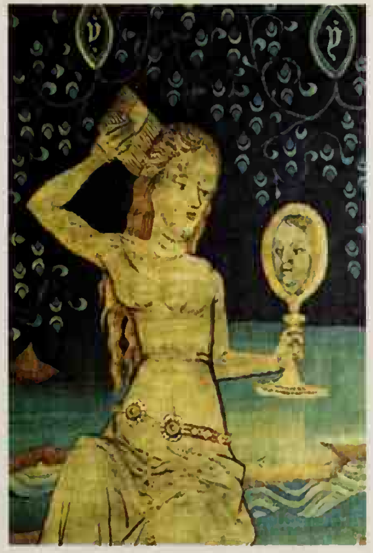
by illuminated manuscripts of the Book of Revelation. By the mid-15th century, Tournai had begun to replace Arras as a center of Burgundian patronage.

During the 16th and early 17th centuries, Brussels became the capital of European tapestry production with large factories established by Pieter van Aelst and Pieter Pannemaker. For Pope Leo X, van Aelst wove the *Acts of the Apostles* (1515–19; Victoria and Albert Museum), after cartoons by Raphael for the Sistine Chapel. With this series he introduced the Italian Renaissance style and the practice of copying paintings to European tapestry design.

Widely admired, Flemish weavers established workshops throughout Europe during the 16th and 17th centuries. The first series woven on Florentine looms was the *History of Joseph* (1547–50; Palazzo Vecchio, Florence), designed by the Mannerist painter Angelo Bronzino. In 1620 a royal tapestry factory was established at Mortlake, England, with Josse Ampe of Bruges, Belgium, in charge of chiefly Flemish workers and weavers. Such provincial manufacturing centers did not (and could not) compete with the French royal factories founded by Louis XIV at Gobelins (1662), Beauvais (1664), and Aubusson (1665). These factories dominated European production for nearly two centuries with tapestry series designed by France's greatest painters.

During the 19th century, when tapestries were in less demand for wall hangings, Beauvais specialized in furniture covers, as Aubusson had since the 18th century (such as the covers with Jean Baptiste Oudry's scenes from the *Fables of La Fontaine*). When Beauvais was amalgamated with Gobelins in 1940, Aubusson became the major center for tapestry design and production in the 20th century—thanks to Jean Lurçat, who settled there for the purpose of creating a new tapestry industry at the request of the French Ministry of National Education in 1939. In 1945, Lurçat, with the artists Marc Saint-Saëns and Jean Picart Le Doux, founded the Association of Tapestry Cartoon-Painters, which pioneered the revival of tapestry as modern architectural decoration, according to the principle that tapestries should be original works of art (not copies after paintings).

A detail from the tapestry set Song of the World *(1957–64), by Jean Lurçat, shows a cosmos of animal and vegetable life surrounded by a ring of fire. (Musée des Tapisseries, Angers.)*

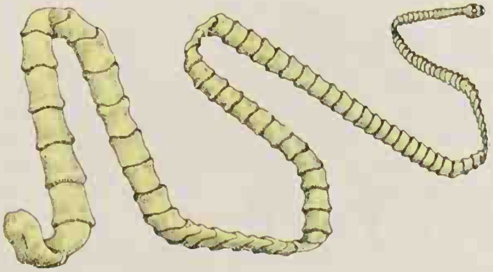


"The Great Whore that sitteth upon the waters," a figure from the Book of Revelation, is depicted in this detail from the Apocalypse of Angers. *The work was woven in wool in 15 colors. (Musée des Tapisseries, Angers.)*

tapeworm A tapeworm is a ribbonlike colony of parasitic flatworms, of the class Cestoda, that infest humans and other vertebrate animals. Species that most commonly infest humans are the beef tapeworm, *Taenia saginata*; the pork tapeworm, *T. solium*; and the fish tapeworm, *Dibothriocephalus latus*.

The tapeworm head (scolex) has hooks or suckers used

An adult pork tapeworm lives in the intestines of humans, folding itself in accordion style to fit its long body into small spaces. A pork tapeworm, which grows up to 10 m (33 ft) long, can live in the small intestine, which is 6 m (20 ft) long. Humans get tapeworms by eating poorly cooked pork that is infested with tapeworm eggs.



to attach the parasite to the host's intestinal lining. The "body" is composed of segments (proglottids) which are separate, sexually functional individuals that can synchronize their muscular activity to keep the colony mobile.

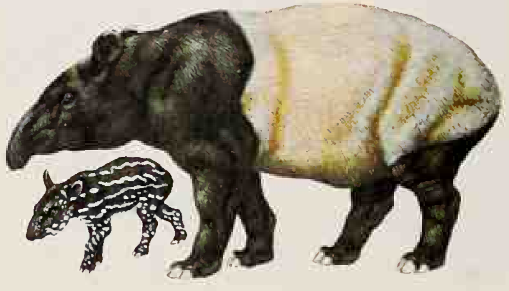
Younger proglottids have testes; as the worms get older, the testes shrivel up and are replaced by ovaries and a uterus. Proglottids having male sex organs release sperm that travel to the older proglottids and fertilize the eggs. Proglottids that contain developing embryos break away and are excreted with feces. Larvae develop and, if the waste matter is eaten by an animal, become dormant and encysted in the animal's muscle tissue. Humans eating poorly cooked animal meat can then ingest the encysted larvae. Adult tapeworm infestations can be eliminated with chemotherapy. Humans, however, can also serve as intermediary hosts, the larvae forming cysts up to 25 cm (10 in) in diameter in the brain, lungs, liver, or other organs. Such infections can only be treated surgically, if at all.

Tápies, Antonio [tahp'-yes] A leading abstract painter of postwar Spain, Tápies, b. Antonio Tápies Puig, Dec. 13, 1923, first exhibited his paintings in 1948. His early works, from 1949 and the early 1950s, show the influence of the surrealists, particularly Joan Miró. His later works focus on his materials; such paintings as *Swirling Sand* (1955; collection of Anthony Denney, London) and *Two Blankets Filled with Straw* (1968; Galerie Maeght, Paris) are mixed-media works combining such raw materials as sand, straw, and cloth with paint. Tápies had his first retrospective exhibition in the United States in 1953.

tapioca see MANIOC

tapir [tay'-pur] The tapir looks like a pig but is related to the rhinoceros and the horse. Four species make up the genus *Tapirus*, family Tapiridae. Tapirs are 1.8 to 2.4 m (6 to 8 ft) long, stand about 1 m (40 in) high at the shoulder, and may weigh more than 270 kg (600 lb). The tapering and sloping face ends in a small, movable trunk. The eyes are small and the ears rounded and erect. The back is rounded, the legs short, and the tail stumpy. Each forefoot has four toes and each hind foot three. The Brazilian tapir, *T. terrestris*, ranges from Colombia and Venezuela to Brazil; Baird's tapir, *T. bairdi*, from southern Mexico to Ecuador; and the wooly Andean, or mountain, tapir, *T. roulini*, from Venezuela to Peru. These three species are reddish brown to black above, lighter below. The Asiatic, or Malayan, tapir, *T. indicus*, is black on the front half and legs and white on the back and sides. Tapirs move quickly in open or jungle habitat and are good swimmers. They feed on almost any plant and also raid farm crops.

An infant Malayan tapir has a patterned coat of spots and stripes that will fade by the time the animal is 1 year old.



Tappan (family) [tap'-uhn] The Tappan brothers were U.S. businessmen and abolitionists. **Arthur Tappan**, b. Northampton, Mass., May 22, 1786, d. July 23, 1865, opened (1826) a silk-jobbing firm in New York City, which became successful because of its cash-and-carry and low-markup policies. In 1827 he began publishing the *N.Y. Journal of Commerce*, which carried both religious and business news. Six years later he cofounded the American Anti-Slavery Society.

Lewis Tappan, b. Northampton, Mass., May 23, 1788, d. June 21, 1873, founded (1841) the first U.S. commercial credit rating agency (the Mercantile Agency), which became Dun and Bradstreet. He started his business career in Boston but soon joined his brother's silk firm in New York City. He also helped to found (1833) the American Anti-Slavery Society but left it seven years later.

taproot see PLANT

tar, pitch, and asphalt Tar, pitch, and asphalt are viscous, sticky, dark brown or black substances that are composed primarily of carbon and hydrogen. Tar is produced as a by-product of the carbonization of coal and of such other organic substances as wood or peat. Pitch is produced from distilling coal tar, wood tar, or petroleum. Asphalt occurs naturally in large deposits, can be extracted from asphalt rock, and is also produced from petroleum. At room temperature, tar and asphalt vary from a solid to semisolid state, whereas pitch is a fluid or semifluid.

Tar and pitch were once of great economic importance in naval stores because they are not soluble in water and were therefore used to caulk wooden ships. The manufacture of tar and pitch from pinewood was one of the earliest major export industries of the American colonies.

Today tar, pitch, and asphalt are used for roofing, making road surfaces, lubricating, waterproofing, insulating, binding, making plastics, and preserving wood, among many other commercial uses.

tar sands Tar, oil, or bituminous sands are loose or partly lithified freshwater or delta sands containing oil that is too viscous to be processed by conventional means. The most important deposits are found in Canada, the USSR, the United States, and Venezuela; the largest are in the northern part of the province of Alberta, Canada. The Alberta Oil Sands include the Athabasca deposit—the world's largest oil field—where commercial sand mining has been undertaken in the oil sands of the McMurray formation. Attempts have also been made to recover crude oil economically from tar sands of the Orinoco Petroleum Belt in Venezuela. Tar sands in the United States are found mainly in Utah, California, and Texas.

Tara [tar'-uh] The hill of Tara, traditionally considered to have been the seat of the high kings of ancient Ireland, is located 32 km (20 mi) northwest of Dublin. Documentary sources, notably the *Dindseanches* (*c.*1000), catalog the individual sites on the hill together with their legendary associations. Among the surviving earthworks on the site, the so-called Banqueting Hall is most reminiscent of other elongated cult-enclosures built by Celtic peoples. The Rath of the Synods, where Saint Patrick reputedly held assembly, has yielded burials and evidence of occupation in the early centuries of the Christian era. The Rath of the Kings, which like other Irish royal sites is enclosed by an external bank with an internal ditch, itself encloses the Mound of the Hostages, shown by excavation to cover a Neolithic passage-grave, and the conjoined earthworks known as the House of Cormac and the House of the Kings. The site apparently was abandoned during the 6th century.

tarantella [tar-uhn-tel'-uh] The tarantella is a rollicking Italian folk dance in 6/8 time in which a couple or several women teasingly pursue and court one another, twirling and capering with increasing speed to the music of a mandolin, guitar, castanets, or tambourine. Some authorities attribute its name to Taranto, the town of its supposed origin. Others refer to the dancing mania called Tarantism, allegedly caused by the bite of the venomous tarantula, which swept Italy in the 15th to 17th centuries.

Taranto [tah'-rahn-toh] Taranto (ancient Tarentum), a port city in the Apulia region of southern Italy, is situated 430 km (270 mi) southeast of Rome on the Gulf of Taranto. With a population of 244,997 (1987 est.), the city has a naval base as well as shipbuilding, fishing, food-canning, and steel-manufacturing industries. Its historic monuments include the Romanesque Cathedral of Saint Cataldo (11th century) and a Byzantine castle rebuilt by the Aragonese (1480).

Taranto was founded by Greeks (8th century BC) and taken by the Romans (272 BC), Ostrogoths (AD 494), Byzantines (540), Lombards (675), Arabs (856), and Normans (1063). It was part of the Kingdom of Naples and then the Kingdom of the Two Sicilies before joining a newly united Italy in 1860. An important base for the Italian navy, Taranto was bombed by the British in 1940 and captured by the Allies in 1943.

tarantula [tuh-ran'-chuh-luh] A tarantula is a hairy, long-legged, long-lived SPIDER found mostly in warm regions. Also sometimes known as bird spiders or monkey spiders, true tarantulas make up the family Theraphosidae; related forms, including funnel-web spiders and TRAP DOOR SPIDERS, are also sometimes grouped as tarantulas. Many species are about 2.5 to 7.5 cm (1 to 3 in) long, with a 13-cm (5-in) legspan, but some South American species are larger. Tarantulas inject a paralyzing venom into prey with their large fangs. They rarely bite humans, however, and although the bite is painful the venom is usually not seriously harmful to humans.

Aphonopelma chalcodes *is a member of the genus of tarantulas of North America. This spider's bite is painful but not dangerous to humans, and some tarantulas can be trained as pets.*

Tarascan [tuh-rahs'-kuhn] The Tarascan Indians, who speak a language remotely connected to Macro-Mixtecan, live near Lake Patzcuaro in Michoacán, Mexico. In pre-Spanish times they numbered at least 200,000 and had their own empire. The Tarascan maintained a neutral position between the Spaniards and the AZTEC, by whom they had never been conquered. They were missionized by Vasco de Quiroga, Bishop of Michoacán (1537–65), whose ideas were influenced by Sir Thomas More's *Utopia*.

Contemporary Tarascan are field farmers. They build their houses of wood, stone, and adobe and live in villages laid out in streets around a central plaza. The primary economic unit is the elementary family household, but large numbers of kinfolk are linked together by a ritual kin network of *compadrazgo* and *mayordomía*. Despite an outstanding pre-Christian feature, the *yácata*, a quasi-pyramidal temple, Tarascans have retained very few pre-Christian beliefs. Even ideas about witchcraft are European. As with many Mexican Indians, their Catholicism is rooted in a 16th-century folk ideology. They number about 60,000 (1980 est.).

Tarawa [tuh-rah'-wuh] Tarawa, a coral atoll in the west central Pacific, about 3,700 km (2,300 mi) northeast of Australia, is the capital of Kiribati. Covering approximately 23 km^2 (9 mi^2), Tarawa has a population of 22,833 (1988 est.). The atoll is a commercial and educational center, with several ports. Mother-of-pearl and copra are exported. One of the fiercest battles in the Pacific theater of World War II was fought there in 1943.

Tarbell, Ida M. [tahr'-bel] Journalist, editor, and biographer Ida Minerva Tarbell, b. Erie County, Pa., Nov. 5, 1857, d. Jan. 6, 1944, became famous as a MUCKRAKER through her articles on political and corporate corruption in *McClure's Magazine* and *American Magazine*. Her two-volume *History of the Standard Oil Company* (1904) led to federal action against the giant corporation. She also wrote a biography (1900) of Abraham Lincoln and an autobiography, *All in a Day's Work* (1939).

Tardieu, Jean [tahr-dee-u'] The experimental French poet, playwright, and radio producer Jean Tardieu, b. Nov. 1, 1903, has been associated with the THEATER OF THE ABSURD since the late 1940s. He explored the limits of theatrical possibility in sketches and one-act plays later collected in *Théâtre de Chambre* (Bedroom Theater, 1955) and *Poèmes à jouer* (Poems to Be Played, 1960). In verse—*Accents* (1939) and *Jours pétrifiés* (Petrified Days, 1948)—Tardieu also experimented with nontraditional forms.

tariff A tariff is a tax levied on goods imported from abroad. A *specific* tariff is levied on each unit of an imported good. An *ad valorem* tariff is levied as a percentage of the value or wholesale price of the good.

Reasons for Tariffs. Historically, tariffs have been used as sources of government revenue in many countries. In the 19th century they were the principal source of revenue for the U.S. government. In recent decades the governments of industrially advanced countries have relied primarily on the income tax and other kinds of taxation for their revenue, although tariffs are still used for this purpose in many developing countries.

Tariffs are also used to protect domestic industries from lower-priced foreign competition. Many countries have low tariffs or none at all on imported raw materials but place higher tariffs on more-processed materials; this device is designed to protect established manufacturing industries without raising the price of raw materials used in production.

Tariffs are imposed for a variety of other reasons. Labor unions often favor tariffs because of the low-wage competition from abroad. A government may use tariffs in an effort to increase the country's gain from INTERNATIONAL TRADE, by keeping import prices lower than export prices. A tariff may be used to protect a particular industry or geographical area that is suffering unusual hardship; or it may be invoked for purposes of national defense, to make a country less dependent on foreign supplies of certain goods. Finally, there is the "infant industry" argument for tariffs: that new industries need protection from foreign competition until they are able to establish themselves.

Arguments against Tariffs. Arguments against tariffs have been enunciated since mercantilist times (see MERCANTILISM) and were stressed by classical economists, such as Adam Smith, who favored FREE TRADE. Each of the arguments for using tariffs has a counterargument. A tariff may enable workers to obtain higher wages by protecting them from foreign competition, but it will require consumers to pay higher prices for imports. It may also be costly if it serves to protect uneconomic, inefficient industries. If a country tries to use tariffs to give it a more favorable balance of trade than it would otherwise have, it runs the risk of retaliation from other countries. Such tariff warfare reduces the volume of international trade, to everyone's disadvantage. When workers in a particular geographic area or industry need assistance because they are unable to move to jobs elsewhere, it is less expensive to subsidize them directly than to protect their existing jobs with a tariff. If a government wishes to promote self-sufficiency for purposes of national defense, a tariff may be much less effective than other alternatives such as stockpiling critical raw materials or subsidizing their production directly. The same holds true for the case of an infant industry; it would be more efficient to subsidize the industry directly than to protect it by a tariff that imposes higher prices on consumers.

Other Ways of Limiting Imports. Tariffs are not the only way of controlling trade. A commonly used device is the import QUOTA, which specifies the maximum amount and sometimes the maximum value of a commodity that can be imported in a given period. Another kind of nontariff measure, used increasingly by the United States, is the voluntary export restraint—the so-called orderly marketing agreement. This is an arrangement under which the foreign exporting country agrees to limit its exports of certain products for a specific period.

Attempts to Reduce Trade Barriers. After World War II the major trading countries established (1947) the GENERAL AGREEMENT ON TARIFFS AND TRADE (GATT) to oversee and limit the use of tariffs and other measures of trade control. This organization has served as a focal point for reducing tariffs and other trade barriers. In the course of a series of negotiations the member countries have agreed to liberalize their trade barriers in a manner that roughly balances the effects on their imports and exports.

See also: BALANCE OF PAYMENTS; CUSTOMS UNION; PROTECTIONISM.

tariff acts In U.S. history, from 1789 to the early 20th century tariffs were the single most important source of federal government revenue and were increasingly used—at ever-higher rates—to protect domestic industry. Subsequently, as internal taxation was increased and mutual tariff reductions were negotiated with other countries to promote international trade, tariffs accounted for a declining share of revenue.

Tariffs were the national government's principal source of revenue until the income tax amendment (the 16th Amendment to the Constitution) was passed in 1913. But sectional and economic differences made them a source of contention from the outset. Northern manufacturers wanted protection for infant industries, but the agrarian South, dependent on cheap manufactures, favored tariffs for revenue only. A compromise was achieved by the first tariff law, passed in 1789. Ad valorem duties, based on assessed value of a commodity, ranged from 5 to 15 percent, the highest rates applying to luxury items and such manufactured goods as cordage, nails, iron, and glass.

New industries built up during the War of 1812 received protection in the increased rates of the 1816 tariff law. Southern leaders protested the even higher schedules of the "Tariff of Abominations" (1828), and South Carolina invoked John CALHOUN's doctrine of NULLIFICATION against the 1832 tariff. Henry CLAY's Compromise Tariff of 1833 set the pace for moderate duties until southern secession.

With the South's absence from Congress during the Civil War and the weakening of the Democratic party (historically favoring a low-tariff policy), the newly formed Republican party granted protection to northern manufacturers. The Morrill Tariff of 1861 and revisions (in 1862, 1864, 1867, and 1869) raised average rates on dutiable goods to 47 percent. In the late 19th century business interests were exerting increasing influence on government, and they secured record duties in the McKinley Tariff (1890) and Dingley Tariff (1897). In the Populist and Progressive eras farmers and small-business proprietors protested that protection was a major cause of monopoly formation. Woodrow Wilson campaigned against the special privileges of the so-called trust in 1912, then secured downward revision in the Underwood Act of 1913.

A desire for economic self-sufficiency among Europe's powers led to a worldwide high-tariff system after World War I. American farmers, faced by international competition, joined businesses in backing the restoration of a protective system with the high duties of the Fordney-McCumber Act (1922) and the Smoot-Hawley Act (1930). Intensified international trade warfare spurred even higher tariffs during the Great Depression of the 1930s. New Deal tariff policies were contradictory. President Franklin D. Roosevelt's recovery program required higher domestic prices, leading to protectionist measures to assist the process of reflation to 1929 price levels. Proponents of expanded foreign trade, however, secured passage of the Reciprocal Trade Agreements Act of 1934, which authorized the president to negotiate with foreign nations for mutual tariff reductions. This reciprocal trade measure promised a historic reversal in U.S. tariff policy.

The change came after World War II, with the emergence of the United States as the world's leading economic power, anxious for worldwide trade expansion. At Geneva in 1947, 23 governments, led by the United States, concluded the GENERAL AGREEMENT ON TARIFFS AND TRADE (GATT), resulting in a lowering of U.S. duties from an average of 54 percent in 1933 to 12 percent by 1963.

Faced by a recession and trade decline, President John F. Kennedy secured the Trade Expansion Act (TEA) of 1962. Congress reaffirmed a policy initiated in 1934 giving the president authority to negotiate downward revision in tariffs by as much as 50 percent in exchange for similar concessions. Under the Kennedy Round (1964–67), sixth in a series of trade conferences sponsored by GATT, duties were reduced by an average of about 35 percent on more than 5,000 items. The TEA allowed federal assistance to businesses, workers, and communities affected by tariff reductions. More recent trends are to use quotas and import-limitation agreements rather than tariffs to protect U.S. industries from foreign competition.

Tariff Commission, U.S. see INTERNATIONAL TRADE COMMISSION, U.S.

Tarim River [dah-reem'] The Tarim River rises as the Yarkand in the Karakoram Range on the Kashmir border and flows through the TAKLI MAKAṆ DESERT in the Xinjiang province of western China. It has a total length of about 2,028 km (1,260 mi). Fed by tributaries from the Tian Shan and the Kunlun mountains, the river often changes its course, flowing through lakes and swamps of the LOP NOR area, where nuclear testing is conducted. Waters from the Tarim irrigate nearby oases.

Tarkenton, Fran [tahr'-ken-tuhn] Francis Asbury Tarkenton, b. Richmond, Va., Feb. 3, 1940, was an American football quarterback who holds virtually all of the career passing records in the National Football League (NFL). After a college career at the University of Georgia, Tarkenton was drafted (1961) by the Minnesota Vikings, and in his first appearance as quarterback he threw for four touchdowns and ran for a fifth. In 1967 he was traded to the New York Giants and played there for 5 years without distinction. Tarkenton was traded back to the Vikings, and between 1972 and 1978 he led them to five consecutive division titles and three Super Bowls. A highly mobile quarterback who "scrambled" out of the reach of pass rushers, Tarkenton gained more yards on the ground than any quarterback in NFL history. During his 18-year career Tarkenton completed 3,686 of 6,467 attempted passes, gained 47,003 yd, and passed for 342 touchdowns, all NFL records.

Tarkington, Booth [tahr'-king-tuhn] Newton Booth Tarkington, b. Indianapolis, Ind., July 29, 1869, d. May 19, 1946, was a prolific American novelist and playwright. He is well known for *Penrod* (1914) and *Seventeen* (1916), sentimental novels dealing with the throes of adolescence. His interest in American society, expressed in a short-lived career in Indiana politics, broadened into *The Magnificent Ambersons* (1918; film,

1942) and *Alice Adams* (1921; film, 1935), both Pulitzer Prize–winning novels.

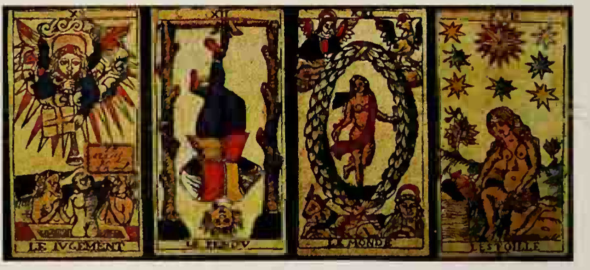
taro [tahr'-oh] Taro, *Colocasia esculenta*, is a perennial tropical plant of the ARUM family, Araceae. Its large, starchy, tuberous roots are a staple food in Polynesia and East Asia. Roots from the wetland taro are heated to destroy their bitter taste, then ground and fermented into an edible paste called poi, an important food on many Polynesian islands. The upland (dry) taro, or dasheen, produces corms that are eaten like potatoes in Japan, China, and the West Indies. The dasheen is sometimes grown as an ornamental houseplant called "elephant's ear" because of its large, heart-shaped leaves.

Taro, a tropical perennial herb, bears large, arrowhead-shaped leaves. It is cultivated in Asia and the Pacific Islands for its starchy, tuberous root (left), *which is a staple food in many cultures.*

tarot [tar'-oh] The oldest playing cards still in common use—both for CARD GAMES and as the basis of a branch of the fortune-telling art—the tarot was brought from the East to Italy in the 14th century by gypsies or returning Crusaders.

The tarot deck consists of 78 cards, which are divided into two distinct groups. The Minor, or Lesser, Arcana, the precursor of the modern deck, is made up of 56 cards divided into four suits. The wands suit corresponds with the modern clubs suit; cups with hearts; swords with spades; and pentacles with diamonds. Each suit has 14 cards, with numbered cards from ace to ten and four unnumbered face cards: king, queen, knight, and knave. (The four knave cards have been eliminated in the modern deck.)

The Major, or Greater, Arcana consists of 22 cards, each bearing a title and a picture. The symbolism of the Major Arcana has fascinated writers and psychologists, who assume that such pictures as the Hanged Man, the Wheel of Fortune, Judgment, and the Moon are medieval allegorical representations of virtues and vices, and life- and death-dealing forces. Twenty-one of the cards are numbered. The 22d card, the Fool, numbered 0, is analogous to the modern joker.



Four cards from a medieval tarot deck are, from the left, Judgment, the Hanged Man, the World, and the Star. The earliest record of playing cards in Europe dates from 1392, when the royal treasurer of King Charles VI of France noted payment to a painter for three sets of tarot. Most early tarot decks were titled in French, and some think, therefore, that the cards may have originated there. Little is known, however, about the symbolism of the Major Arcana cards.

In fortune-telling, either the full pack or the Major Arcana alone is used. The relationship of one card to another, as laid out in a number of different configurations, is as important as the significance of each individual card. The Italian card game *tarrocchi* is still played in southern and central Europe.

tarpan [tahr'-pan] The tarpan is a wild horse that became extinct in Europe during the early 20th century. Also sometimes known as the European wild horse, the tarpan was short and had a long head, a thick neck, an upright mane, and a gray to brown coat with a dark back stripe. Once roaming by the thousands over Europe and parts of Asia, tarpans are believed to have been important sources of food for prehistoric humans. Horses much like the tarpan have been bred in Munich through selective breeding of horses with tarpan ancestry.

tarpon [tahr'-pahn] The tarpon, *Megalops atlantica*, is the famous "silver king" of big-game anglers, noted for its spectacular leaps when hooked. It is found from Brazil to North Carolina and sometimes as far north as Cape Cod and off the Atlantic coast of Africa. A primitive bony fish, the tarpon can breathe with a gas bladder as well as with gills. It reaches more than 2.4 m (8 ft) and 135 kg (300 lb) and has a long, forked tail and a

The tarpon is abundant near the Florida and Carolina coasts and ranges from Cape Cod to Brazil.

dorsal fin with an enlarged last ray; its color is blue on the back and silvery on the sides and belly. The larvae are transparent and ribbonlike.

Tarquinia [tahr-kwin'-ee-uh] According to Greek and Roman tradition, Tarquinia (Roman: Tarquinii)—in central Italy about 96 km (60 mi) north of Rome—was the foremost among ETRUSCAN cities in both wealth and age. Archaeological evidence has since shown that the city was already important in VILLANOVAN times (8th century BC). A 6th- to 3d-century-BC Greek sanctuary was unearthed (1969) at Tarquinia's port of Gravisca. The town of Tarquinia was first uncovered in 1934–38, when its fortifications and a large 3d-century-BC temple were excavated. Tarquinia is most famous for the paintings in the chamber tombs of its necropolis, which exemplify the evolution of the Etruscan style from the 6th century BC onward. Several examples of the archaic period (6th century BC) illustrate banquets, dances, athletic contests, and games featured at aristocratic funerals, thus providing insights into Etruscan daily life.

Tarquinius Priscus, Etruscan King of Rome [tahr-kwin'-ee-uhs pris'-kuhs] According to Roman tradition, Lucius Tarquinius Priscus, d. 578 BC, was an Etruscan who ruled (616–578 BC) Rome as its fifth king, following Ancus Marius (r. *c.*641–616 BC). Priscus is credited with subduing the Sabines and the Latins; draining the marshes; building the Circus Maximus, the Forum, and the Capitoline temple; and infusing Roman institutions with elements of Etruscan culture. He was supposedly assassinated at the behest of Ancus's sons.

Tarquinius Superbus, Etruscan King of Rome [soo-pur'-buhs] Lucius Tarquinius Superbus (Tarquin the Proud), the last of Rome's seven kings, ruled, according to tradition, from 534 to 510 BC. The son of Tarquinius Priscus, he supposedly murdered his father-in-law, Servius Tullius (r. 578–534), to succeed to the throne. According to tradition, he was expelled by a Senate-led revolt provoked by his son's rape of LUCRETIA. The Romans then established the republic. Superbus vainly sought to reinstate himself, aided by LARS PORSENA.

tarragon Tarragon is a perennial herb, *Artemisia dracunculus,* that is prized for its fragrant leaves, particularly in France. Native to southwestern Asia, the plant is now cultivated in sunny and dry locations throughout the temperate zones. It reaches a height of 90 cm (3 ft) and has many stems. The leaves are 25–100 mm (1–4 in) in length. The plant is usually propagated by stem cuttings or root divisions. The leaves are used fresh or dried.

Tarragona [tah-rah-goh'-nah] Tarragona, a port city in Catalonia, northeastern Spain, lies on the Mediterranean coast, about 80 km (50 mi) southwest of Barcelona. The population is 107,356 (1987 est.). Tarragona's industries process foods and tobacco; wine and olives are exported. Ruins of a Roman amphitheater, aqueduct, and forum as well as a Gothic cathedral (12th–13th century) are major landmarks. Captured by the Romans in 218 BC, the city was ruled by the Moors from AD 714 to 1117.

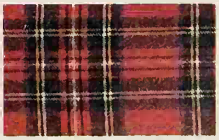
tarsier [tahr'-see-ur] The tarsier is an arboreal, mainly nocturnal, rat-sized primate of the genus *Tarsius* found on southeastern Asian islands. It has a rounded head that can be turned almost in a circle, large ears, large staring eyes, and a pug nose. The small, gray brown body has long hind legs and a long, usually naked tail. Elongated digits tipped with rounded pads for gripping help the animal in its agile acrobatics. It preys on insects and other small animals.

The tree-dwelling Philippine tarsier is a primitive relative of true monkeys. Its large eyes are adapted for seeing at night.

Tarsus [tahr'-suhs] Tarsus is an ancient port city on the Tarsus (Cydnus) River in southern Turkey, about 400 km (250 mi) southeast of Ankara. The population is 146,502 (1985). Located about 16 km (10 mi) inland, it serves fishing and coastal trading vessels at the east end of the Mediterranean. Tarsus is an agricultural and cotton-milling center in the heart of the fertile Cilician plain. A Roman temple and archaeological sites attract tourists.

Tarsus became capital of the Roman province of CILICIA in 67 BC. Mark Antony and Cleopatra first met (41 BC) in Tarsus, and the Apostle Paul was born there. Located between the Mediterranean and the Cilician Gates—the major pass through the Taurus Mountains—it had strategic importance. Tarsus was controlled at various times by Assyrians, Persians, Greeks, Romans, Byzantines, Arabs, and Crusaders but finally fell to the Ottoman Turks in 1515.

tartan A tartan is a plaid pattern, now primarily associated with Scotland, that has come to be regarded as a heraldic device or badge that designates major Scottish CLANS, families, and districts. Such patterns, however,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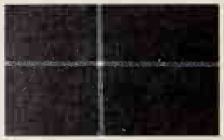
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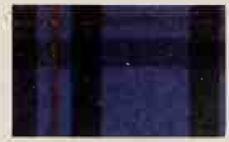
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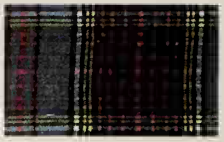
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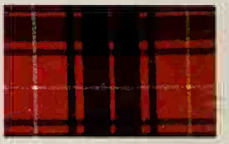
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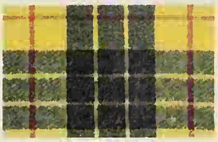
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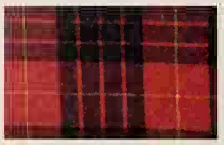
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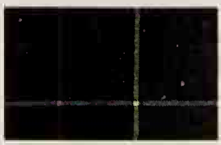
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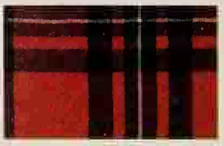
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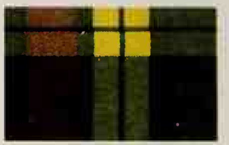
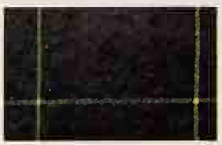

Ancient MacMillan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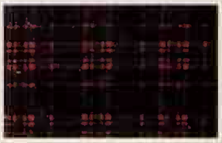
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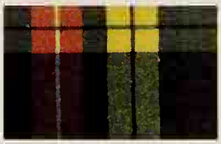
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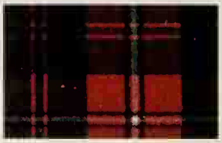
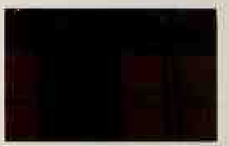

Cunningham


Lindsay

have existed for centuries in countries as disparate as Italy and Japan. The design, or sett, of a Scottish tartan consists of colored bands or lines of specific width and sequence crossing at right angles against a solid ground and usually woven into woolen cloth or wool and silk. Although the tartan may be made in any size, the proportions of the stripes must remain constant. Traditionally, extra lines have sometimes been added to indicate rank.

Tartans were originally worn by Scottish Highlanders as a single, large, rectangular cloth folded lengthwise and belted at the waist. The bottom portion fell in loose pleats; the upper and longer section was worn draped about the shoulders and pinned. During inclement weather it served as a protective cloak. The smaller kilt (knee-length pleated skirt) and plaid (rectangular length of tartan cloth placed over the left shoulder), now separate, were apparently derived from this costume during the early 17th century.

The use of checkered garments is ancient. The Irish, Britons, Caledonians, and Celts wore them, both men and women. In Scottish literature the earliest references to tartans date from the 13th century. At first tartans represented districts in Scotland; later they became the badge of the chief clans or families of an area. After the Jacobite Rebellion of 1745, Highland dress and the tartan were proscribed until 1782. Some old setts were lost in the intervening period, but many new ones were invented when military tartans for the Scottish regiments were subsequently approved by the government.

Tartar see TATAR

Tartarus [tahr'-tuh-ruhs] In Greek mythology Tartarus was variously the lowest region of the underworld or synonymous with the underworld (HADES), where Uranus banished his rebellious sons, the Cyclopes, and according to Homer, Zeus later confined the defeated Titans. According to one creation myth, based on Hesiod, Tartarus was born of the union of air and mother earth; the giants, of the union of Tartarus and earth.

Tartini, Giuseppe [tahr-tee'-nee] Giuseppe Tartini, b. Apr. 8, 1692, d. Feb. 26, 1770, was an Italian violinist, composer, theorist, and founder (1728) of a school of violin playing in Padua that was famous throughout Europe. He studied at Padua and elsewhere, held various posts as violinist, and was conductor (1723–25) of Count Kinsky's orchestra in Prague. He improved the violin bow and wrote important treatises on playing the instrument and acoustics. His approximately 300 compositions include more than 100 concertos, numerous solo and trio sonatas, and some church music.

Tartu [tahr'-too] Tartu is the second largest city of Estonia, in the USSR. The population is 114,000 (1989). In addition to its Estonian name of Tartu, the city was formerly known as Yur'yev (its historical Russian name) and Dorpat (its German name). Tartu is situated on the banks of the Emajogi River between Estonia's largest lake, Võrtsjärv, and Lake Peipus. It is a manufacturing center, linked by railroad with Tallinn, and it produces tools, instruments, footwear, lumber, and farm machinery. Its development as an educational and cultural center was associated with the founding of Tartu University (1802), which succeeded the Gustavo-Caroline Academy (1632). First mentioned in the 11th century, Tartu has the ruins of a 13th-century cathedral, a botanical garden dating from the 19th century, and an agricultural academy.

Tarzan of the Apes A fictional hero created by Edgar Rice BURROUGHS in the 1912 novel *Tarzan of the*

Apes, Tarzan was the main character of 23 other novels Burroughs wrote periodically through 1944. Adopted and raised to adulthood in Africa by a tribe of great apes, Tarzan later discovers that he is a British lord and thereafter divides his life between London and Africa, where he is "the Lord of the Jungle." Tarzan was the hero of about three dozen movies, a radio series, a comic strip, and several television series in the United States.

Tasaday [tahs-ah'-dy] The Tasaday, a people of southern Mindanao in the Philippines, have been at the center of one of the most heated modern anthropological debates. Numbering about 25 people in 1971, when they were discovered by government officials, the Tasaday were purported to be a modern-day Stone Age tribe with no knowledge of agriculture, weaving, or pottery. Articles in the popular press and John Nance's 1975 book, *The Gentle Tasaday*, portrayed a people with a distinct language and—due to the daunting surrounding terrain—no previous contact with the outside world. The Tasaday reportedly lived in caves, wore scant clothing devised of leaves, fashioned tools of bamboo and stone, gathered fruits and plants in the rain forest, trapped wild game, and caught fish by hand.

The Tasaday people captured the public's imagination and caused great excitement in anthropological circles, but from the outset some anthropologists doubted the Tasaday story. Among other inconsistencies, critics have noted that agricultural villages are close enough for the Tasaday to have made contact; that the area in which the Tasaday live is too resource poor to support a HUNTER-GATHERER life-style; that the Tasaday language is very close to the Manobo language spoken in surrounding areas; and that no trash heaps, or middens—indicators of long occupation—have been found in or near Tasaday caves. Many anthropologists regard the Tasaday story as a hoax perpetrated for political gain by Philippine government officials.

Tashkent [tash-kent'] Tashkent is the capital of Uzbekistan, a republic in the USSR, and the administrative center of Tashkent oblast. The population is 2,073,000 (1989). Tashkent is the largest city of Soviet Central Asia and is a manufacturing and transport center. It is situated in the foothills of the TIAN SHAN system in an oasis irrigated by the Chirchik River.

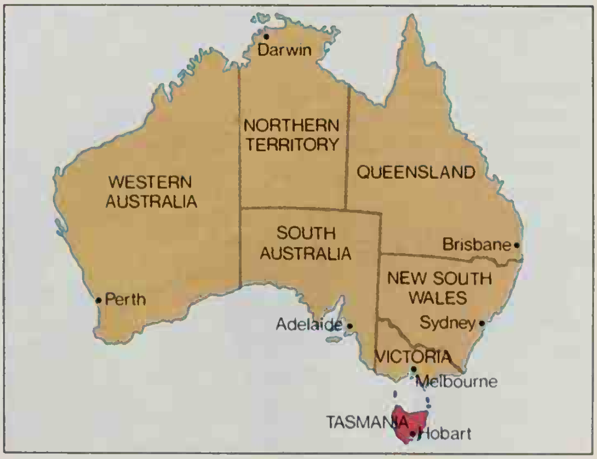
The city's manufacturing plants produce agricultural equipment, excavators, compressors, hoisting machinery, ball bearings, light bulbs, and electric cables. Tashkent also has Central Asia's largest cotton-textile mill. A cultural and educational center, Tashkent has a university (1920), a conservatory, and specialized engineering schools. An opera and ballet theater and both Uzbek and Russian drama theaters are based there. The city's museums include one on the history of Uzbekistan and an Uzbek arts museum.

In existence since the 2d century BC, Tashkent became a Muslim city in the 8th century AD and was an important commercial center during the Middle Ages. Annexed by Russia in 1865, it now consists of an old Asian section and a modern city. Rail connections with Russia were completed in 1898, and industrial development followed. The city's growth was spurred in World War II, when many industries relocated there from the European part of the USSR. A devastating earthquake took place there in 1966.

Tasman, Abel Janszoon [taz'-muhn] Abel Janszoon Tasman, *c.*1603–*c.*1659, a Dutch East India Company navigator, was the first European to discover Tasmania, New Zealand, Tonga, and the Fiji Islands. In 1633 he began a series of trading visits to the East Indies and later to Japan. On his most famous mission (1642–43)—to the southern Pacific—he made his major discoveries, including Van Diemen's Land (now Tasmania). He also sailed around the continent called the Great South Land (later Australia), establishing that it was not connected to the polar continent. In 1644, having been sent out again to clarify Australia's relationship to Tasmania and New Guinea, Tasman found a passage into the Pacific north of Australia's Gulf of Carpentaria. After missions to Siam (1647) and against the Spaniards (1648), he retired from the sea.

Tasman Sea The Tasman Sea is a 2,250-km-wide (1,400-mi) arm of the Pacific, with Australia to the west, New Zealand to the east, the Coral Sea to the north, and the Southern Ocean to the south. Noted for strong winds and storms, it has a maximum depth of 5,200 m (17,000 ft). Named for Abel Janszoon Tasman, it was explored by James Cook during the 1770s.

Tasmania [taz-may'-nee-uh] Tasmania, Australia's island state lying approximately 240 km (150 mi) south of



Victoria in the South Pacific Ocean, covers 68,329 km^2 (26,383 mi^2) and has a population of 449,300 (1988 est.). Slightly smaller than the state of Maine, it accounts for less than 1% of Australia's area. The capital is HOBART, located on the southeast coast. Mountainous, with peaks in the west exceeding 1,500 m (5,000 ft), Tasmania is an extension of the continent's Eastern Highlands. Lakes are abundant, especially in the wetter western areas. Natural vegetation is dense forest, often composed of eucalyptus.

In contrast to other Australian states, where a majority of the people live in the capital, only about 40% of Tasmania's citizens reside in Hobart. Launceston (1988 est. pop., 63,250), closer to the mainland, is the second largest city. About a fourth of the population are rural. Tasmania's English-speaking populace, mostly of British ancestry, has grown at a slower rate during the 20th century than that of other states, and Tasmania has received few of Australia's recent immigrants.

The island has abundant hydroelectric power, and this cheap energy source has attracted some major industries. Lead, zinc, copper, and tin are mined. Industries manufacture paper products, textiles, and candy. Mixed farming is found throughout the island; wool, lamb, dairy products, potatoes, berries, and apples are leading commodities.

Known as Van Diemen's Land until 1855, the island was renamed for Abel Janszoon Tasman, the Dutch navigator who discovered it in 1642. Permanent European settlement dates from 1803 at Risdon. Initially part of New South Wales, the island became a separate colony in 1825 and a state in 1901.

Tasmanian devil The Tasmanian devil is a carnivorous marsupial, *Sarcophilus harrisi*, of the family Dasyuridae, now found only in Tasmania but once widely distributed throughout Australia. The squat, low-slung body with its squarish head may grow to 80 cm (31.5 in) long and the tail to about 30 cm (12 in) long. Males may weigh 9 kg (20 lb) or more. The coarse, brown black coat has white patches on the face, sides, and chest. The jaws and teeth are massive bone crushers. Tasmanian devils feed at night on small animals and carrion. Up to four young are carried in the pouch for about 3½ months.

Tasmanian languages see OCEANIA, LANGUAGES OF

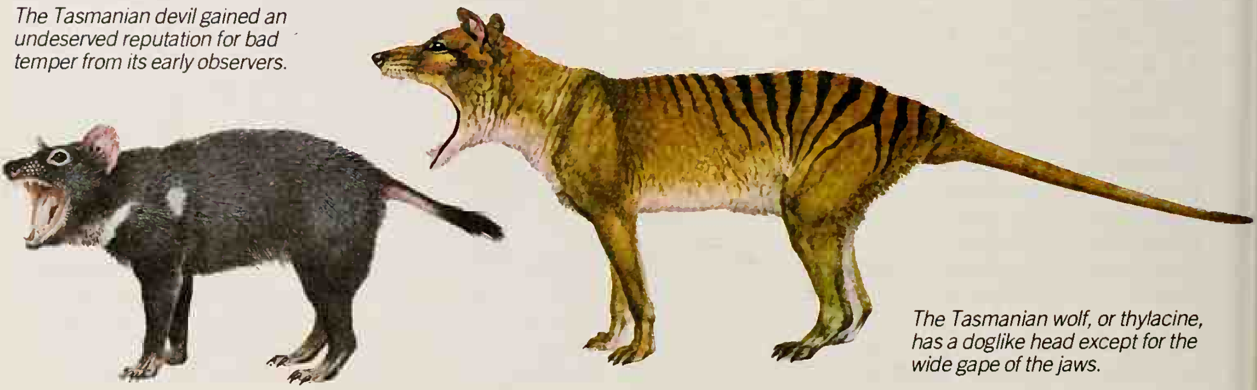
Tasmanian wolf The Tasmanian wolf, or thylacine, a carnivorous marsupial, *Thylacinus cynocephalus*, was once common in Tasmania and Australia but was killed in large numbers because of its occasional attacks on sheep. The last known thylacine died in a zoo in 1936, but reports of sightings still occur. The animal is about 1 m (40 in) long, plus a thick-based tail of about 63 cm (25 in). Its tawny coat is marked with up to 19 dark bands on the back, giving it the alternative name of Tasmanian tiger. Few reliable observations of its behavior in the wild exist, but its prey was known to include small mammals and birds.

Tass News Agency see PRESS AGENCIES AND SYNDICATES

Tasso, Torquato [tahs'-soh, tohr-kwah'-toh] The greatest poet of the Italian High Renaissance, Torquato Tasso, b. Sorrento, Mar. 11, 1544, d. Apr. 25, 1595, is known above all for his epic masterpiece, *Gerusalemme liberata* (1581; trans. as *Jerusalem Delivered*, 1594, 1600), and for the influence he exerted on English literature.

The publication of a romantic narrative poem, *Rinaldo* (1562), when he was only 18 years old, gave early evidence of Tasso's genius. In 1565 he entered the service of Cardinal Luigi d'Este, transferring in 1572 to the brilliant court of Duke Alfonso II d'Este in Ferrara; under their patronage he produced important *Discourses* on the art of poetry (1567; published 1587) and the charming pastoral drama (see PASTORAL LITERATURE) *Aminta* (performed 1573; published 1580; Eng. trans., 1591), the most influential Renaissance example of its genre.

A first "authorized" edition of *Gerusalemme liberata* appeared in 1581; although a heavily revised, much in-



The Tasmanian devil gained an undeserved reputation for bad temper from its early observers.

The Tasmanian wolf, or thylacine, has a doglike head except for the wide gape of the jaws.

hibited version bearing the title *Gerusalemme conquistata* (Jerusalem Conquered) was published by the poet in 1593, it is on the first that his high reputation in Italian letters is based. In this epic of the recapture of the Holy City from the Saracens during the First Crusade, Tasso attempted to fuse the epic form of Vergil with chivalric content and Christian morality; it is the beauty of the lyrical passages and the vitality of the characterization that give the work its enduring value.

Tasso is also admired for his Petrarchan love poetry (*Rime*, 1591, 1593); for his *Dialoghi* (1585–89; trans. by Thomas Kyd as *The House-holder's Philosophy*, 1588), on philosophical, moral, literary, and aesthetic subjects; and for about 1,700 letters (*Lettere*, written 1579–86, published 1852–55).

taste and smell Taste (gustation) and smell (olfaction) are two senses that work together in humans to determine the flavor and palatability of foods and beverages and to signal the presence of dangerous gases and toxic foodstuffs. In many animals, these senses play a critical role in locating food, detecting predators, and recognizing appropriate mating partners.

Despite their close association, taste and smell are anatomically and functionally distinct. In the case of taste, chemicals that evoke sweet, sour, bitter, or salty sensations stimulate taste-bud receptors located in the throat and on the TONGUE and palate. This stimulation triggers nerve cells to send signals to the brain stem located in the base of the brain. Odors register in the brain when airborne chemicals stimulate receptors located on the olfactory epithelium, a small patch of tissue positioned high in the NOSE. These receptor cells send signals into the brain through a thin section of the skull located between the eyes, termed the cribriform plate. Signals are conducted from an overlying olfactory bulb to higher brain centers associated with arousal, emotional phenomena, and cognition.

The olfactory system is vitally important in determining food flavors. During chewing and swallowing, odor-laden air is forced from the rear of the oral cavity to the olfactory receptors, evoking many flavor sensations that people usually associate with taste but that are almost completely dependent on the sense of smell. If the nose is held while food is being swallowed, the free flow of air to the olfactory receptors is prevented, resulting in a decrease in or elimination of the perception of the food's taste.

Numerous factors influence the ability to smell. For instance, women, on average, have a better sense of smell than do men. Older persons typically develop anosmia, or loss of smell function. Various diseases, head injuries, and exposure to airborne toxins, including cigarette smoke, may cause a lessened smell function or a distortion of smell function, such as perceiving a bad smell while smelling flowers. Recent studies suggest that alterations in the ability to smell may be an early sign of Alzheimer's disease and parkinsonism.

Fewer factors influence taste perception. Cigarette smoking tends to lessen taste by dulling the ability to taste bitter-tasting chemicals. Some medications distort taste by inducing unpleasant or persistent taste sensations.

See **also:** SENSES AND SENSATION.

taste buds see TONGUE

TAT see PROJECTIVE TESTS

Tatar [tah'-tur] The Tatar, sometimes corrupted to *Tartar*, are descended from Caucasoid Volga Bulgars, but they became mingled with MONGOLS during the 13th century. They speak Kipchak Turkic, a URAL-ALTAIC LANGUAGE. In the 1980s more than 6 million Tatar lived in the USSR; the remaining hundred thousand or so lived in China, the Balkans, and Anatolia. About half of the Tatar people are Hanafi-Sunni Muslims (see SUNNITES). Social structure remains based on the father's family, but such Muslim traditions as bride-price and marriage to multiple wives are virtually nonexistent; the DOWRY custom and year-long wedding rituals are disappearing. Most Tatar now live in cities, and urban Tatar often intermarry with Russians and Volga Finns.

Arriving from the southern steppes during the 7th century, Volga Bulgars mixed with local Finns, producing the Tatar people. During the 13th century hordes of Mongols suddenly appeared under the leadership of GENGHIS KHAN, terrifying and laying waste the civilized world. After the Mongol conquest of their land, the Tatar gradually assimilated with their conquerors, and the combined population kept the name *Tatar*, or *Tartar* (from a Greek word signifying hell and here used to describe the Mongol ruthlessness).

Tate, Allen [tayt] An American poet and critic, John Orley Allen Tate, b. Winchester, Ky., Nov. 19, 1899, d. Feb. 9, 1979, was a founding member of the "Fugitives," a group of Vanderbilt University students and teachers who believed in the traditional values of the agrarian South. Tate's familiarity with Latin literature is suggested by his complex, ironic poems, many of which are collected in *Poems* (1960) and *The Swimmers and Other Selected Poems* (1970). He won the Bollingen Prize in poetry in 1956. His 1938 essay "Tension in Poetry" became an important statement of the principles of the NEW CRITICISM. *On the Limits of Poetry* (1948) and *Essays of Four Decades* (1969) are also notable among his critical works. His novel, *The Fathers* (1938), elegizes the spiritual side of the antebellum South.

Tate Gallery, The The Tate Gallery in London, originally known as the National Gallery of British Art, was opened in July 1897 in a building designed (1894) by Sidney J. R. Smith and donated to the British government by Henry Tate, who also donated about 65 paintings and 3 sculptures to found the museum's collection. Originally conceived as a showplace for contemporary

British art, the Tate gradually evolved into a more broadly based museum containing British paintings of all periods, the national collection of modern British and foreign sculpture, and the national collection of modern foreign paintings.

The holdings of the Tate cover the works of the British school of art from its beginnings in the 16th century; an added building (1987) designed by James STIRLING houses works by J. M. W. Turner. The Hugh Lane bequest of French 19th-century paintings began (1915) the museum's National Gallery of Modern Foreign Art, which now includes a significant body of impressionist and postimpressionist works. The collection of modern sculpture, which originated in the acquisition of a group of bronzes by Auguste Rodin, has expanded to cover most of the principal modern sculptors.

Tati, Jacques [tah-tee'] The French film director Jacques Tati, b. Oct. 9, 1908, d. Nov. 5, 1982, began his career as a mime and established himself as an actor, writer, and director with *Jour de fête* (1947). Subsequently, he created the brilliant comic figure of Mr. Hulot, who appeared in *Mr. Hulot's Holiday* (1953), *Mon Oncle* (1958), and *Traffic* (1971). Hulot also appears as a background figure in Tati's masterpiece, *Playtime* (1967), a gently humorous study of contemporary civilization.

Tatlin, Vladimir Yevgrafovich [taht-leen'] The Russian painter and sculptor Vladimir Yevgrafovich Tatlin, b. Dec. 28 (N.S.), 1885, d. May 31, 1953, was the founder of CONSTRUCTIVISM, which grew out of his interest in exploring the sculptural possibilities of various "modern" materials—glass, concrete, wire, sheet metal—through abstract reliefs and constructions. In 1913 he visited Pablo Picasso in Paris. The encounter revolutionized his outlook and prompted him to launch his artistic experiments. In 1919 he began plans for a concert-lecture-exhibit hall to be called *Monument to the Third International* (never carried beyond a scale model). A union of architecture, sculpture, light, painting, and motion, it would have consisted of two cylinders and a glass pyramid rotating at different speeds and encircled by a spiral tower 400 m (1,312 ft) high.

tattoo see BODY MARKING

Tatum, Art [tay'-tuhm] The jazz pianist Arthur Tatum, b. Toledo, Ohio, Oct. 13, 1910, d. Nov. 4, 1956, was one of the first great virtuosos of the JAZZ keyboard and exerted a strong influence from the 1930s until his death. Tatum recorded and performed extensively both as a soloist and with his jazz trio. Although others before him, notably Fats Waller and Earl Hines, had done much to move jazz piano away from the old-time ragtime and stride styles, Tatum completed the process with his silky touch, fleetness, and harmonic imagination.

Tatum, Edward L. Edward Lawrie Tatum, b. Boulder, Colo., Dec. 14, 1909, d. Nov. 7, 1975, an American geneticist and biochemist, shared the 1958 Nobel Prize for physiology or medicine with Joshua LEDERBERG and George W. BEADLE for fundamental work in molecular genetics. Tatum, with Beadle, proved that genes regulate biochemical processes; with Lederberg, he demonstrated the existence of genetic recombination in bacteria and, as such, a form of sexual reproduction. He also helped elucidate genetic determination of inherited characteristics and the role of cytoplasmic inheritance.

Tauler, Johannes [tow'-lur] A German Dominican preacher and mystic, Johannes Tauler, b. *c.*1300, d. June 16, 1361, was one of the greatest medieval preachers. His style was simple and direct, and the spiritual and intellectual content of his sermons, which called for detachment and abandonment to the Holy Spirit, met the needs of his listeners, often Dominican nuns. In the 1320s, however, Tauler and his fellow Dominican Heinrich Suso came under the influence of Meister ECKHART. Commonly known as the Rhineland mystics, these three were the inspiration for the Friends of God and other late-medieval mystical movements.

Taung skull see AUSTRALOPITHECUS

Taurus [taw'-ruhs] Taurus, the Bull, is a zodiacal constellation that appears northwest of Orion high above the southern horizon on January evenings in mid-northern latitudes. One of the oldest of the star groups mentioned in ancient records, it marked the position of the Sun on the first day of spring more than 4,000 years ago. Taurus contains the orange-hued star Aldebaran, the 13th brightest star in the sky and 45 times larger than the Sun. The two most famous star clusters—the HYADES and the Pleiades (see PLEIADES, astronomy)—are located in Taurus. Along with numerous double stars, it also includes the CRAB NEBULA (M1), one of the strongest radio sources in the heavens.

Taurus Mountains The Taurus Mountains stretch for about 485 km (300 mi) along the southern rim of Turkey's Anatolian Plateau, parallel to the Mediterranean Sea, from Egridir Lake in the west to the Seyhan River in the east. Demirkazik (3,910 m/12,829 ft), in the easternmost part, is the highest peak in the main range. The rugged limestone terrain makes it difficult to exploit the mineral resources. The thinly populated region is crossed by the Cilician Gates and by four smaller passes.

Tawfiq Pasha [tow-feek' pah-shah'] Muhammad Tawfiq Pasha, b. Apr. 30, 1852, d. Jan. 7, 1892, was Egypt's khedive (viceroy) from 1879 to 1892, during the establishment of Britain's protectorate over Egypt. He succeeded his father, Khedive Ismail Pasha, after the latter's deposition by his nominal Ottoman overlord at the urging of European financiers. Tawfiq, who had little political support, was a passive figurehead whose main ambition was to retain his throne. He was dominated successively by European financial advisors, by the ultranationalist minister of war Arabi Pasha (following an army rebellion led by Arabi), and finally by Lord Cromer's British occupation regime, established after the British invasion of 1882.

Tax Court, U.S. The United States Tax Court is a court of the federal government that hears cases brought by taxpayers who challenge decisions of the Internal Revenue Service (IRS) dealing with overpayment or underpayment of taxes. In many instances the decisions of the U.S. Tax Court can be appealed to the U.S. Court of Appeals and ultimately to the Supreme Court. When taxpayers agree to the use of simplified court procedures in disputes involving $5,000 or less, however, the cases tried under these procedures cannot be appealed to a higher court. The U.S. Tax Court also decides disputes over the rights of taxpayers to see documents and other materials that are related to their cases and that are contained in IRS files.

The court is composed of 19 judges appointed for life and 13 special trial judges who are appointed by the chief judge. It is augmented by retired judges when the case load is heavy. The court's offices are in Washington, D.C., but it holds trial sessions throughout the United States.

taxation Taxation is the imposition of a mandatory levy on the citizens of a country by their government. In almost all countries tax revenue is the major source of financing for public services.

History. Despite the adage that nothing is certain in the world but death and taxes, taxation has not always been the chief source of revenue for governments. The Athenians, for example, had use of the revenues from publicly owned mines and tribute from conquered countries. Revenue from government-controlled resources also provides an alternative or supplement to taxation in some modern societies.

During the Middle Ages, kings derived most of their income from their feudal holdings and generally needed to levy taxes only to pay for their expensive wars. Because ordinarily such taxes could be collected only with the consent and aid of nobles and other large landholders, monarchs found it necessary to call these landholders into session to approve such taxation. These sessions of landholders evolved into parliaments and other legislative bodies. Thus the need of the monarchy for tax revenues can be said to have been one of the causes of the rise of parliamentary government. In fact, many of the constitutional changes that have taken place in the modern world have resulted from the struggle between monarch and legislature over the collection of taxes. In Great Britain, the Glorious Revolution of 1688 established Parliament's authority over taxation.

In the United States, state and local units of government use the income tax, which is the mainstay of the modern federal revenue system, but rely on other tax sources to a greater extent than does the national government. The property tax has traditionally been the backbone of the local revenue system. In addition, most states and many local units of government impose sales taxes. Taxes on tobacco, alcohol, gasoline, and amusement are levied by nearly all states. Most also impose inheritance taxes.

Classifying Taxes. Ultimately, taxes are the price paid for publicly provided services. In a democracy, a majority of citizens (or their representatives) vote to impose taxes on themselves in order to finance public services on which they place value but which they believe cannot be adequately provided by market processes.

Taxes, which drain money from the private sector, must ultimately be paid by a reduction in private consumption or investment expenditures. Determining which individuals or households actually reduce their private consumption or wealth as a consequence of a tax is not always straightforward. The economic units that are nominally assigned legal tax liability are often able to shift the actual burden of the tax onto other sources. Some taxes are not shifted at all; others may be only partially shifted.

Whether or not a tax is shifted provides one basis for classifying taxes. A tax is said to be direct if the economic unit that is legally assigned tax liability bears the full burden of the tax. The personal income tax, for example, is generally regarded by economists as a direct tax. An indirect tax is one that is shifted either wholly or in part. Any tax legally imposed on a commodity (see sales tax; value-added tax) must be an indirect tax because ultimately only individuals can bear the burden of taxes. An indirect tax is said to be shifted forward if consumers of the taxed object bear the tax burden in the form of a higher price for the good. Backward shifting occurs when suppliers of productive resources to a taxed industry earn lower incomes as a result of the tax.

In addition to the direct-indirect classification, taxes are also classified as being either proportional, progressive, or regressive. This classification depends on the relationship between the size of the tax base (the value, income, or wealth being taxed) and the average tax rate applied to that base. If the average tax rate remains constant when the tax base varies in size, the tax is a proportional one. If the rate increases as the base increases, the tax is progressive. A regressive tax is characterized by the tax base and average tax rate varying in opposite directions. A slightly different definition of progressive, proportional, or regressive taxation is useful for analyzing indirect taxes. Under this definition, the tax burden is traced to the actual bearer and then related to income or wealth. A tax is progressive in this case if the tax burden expressed as a percentage of the income of the taxpaying unit rises with income. It is proportional if the tax burden is a constant proportion of income, and the tax is regressive if income received and the percentage of income paid in taxes vary in opposite directions.

Excess Burden. The direct burden of a tax borne by the individual taxpayer is the transfer of purchasing power from the individual to the public sector. If, in addition, the tax distorts taxpayers' choices in ways that prevent them from attaining maximum satisfaction with their remaining income, the tax is said to have generated an excess burden. The personal income tax can provide an example of this problem. Suppose an individual is earning an hourly wage of $5 and, given that wage, chooses to work 50 hours per week. In his or her opinion the $5 received for the 50th hour of work exactly compensates for the hour of leisure activity foregone in order to earn it. The additional $5 that could be earned by working a 51st hour is not enough in his or her view to compensate for that additional hour of leisure activity foregone. Now, suppose that an income tax of 10 percent is imposed. For each hour the individual works, the government collects $0.50 in tax revenue. At the lower net hourly wage of $4.50, the individual may choose to reduce his or her work effort to 42 hours per week. That individual's gross earnings are now $210, out of which $21.00 in tax revenue is collected.

To see how an excess burden may have been generated by the income tax, consider the following alternative way of collecting the same amount of tax revenue from the individual. Suppose that the taxing scheme simply assessed a fixed tax liability or lump-sum tax (also called a capitation, or head, tax) of $21.00 on the individual regardless of how large or how small his or her money income was. Now he or she might well choose to work more than 42 hours per week in this taxing scheme because the net monetary reward for the 43d and each successive hour of leisure foregone is now $5 rather than the $4.50 obtained under the income tax. Given the fixed tax liability of $21.00, the individual now possibly might choose to work the same 50 hours per week as he or she was working prior to imposition of any tax. Tax revenue and, implicitly, publicly provided services remain the same under both the income tax and the lump-sum tax, but with the latter tax, the individual is able to make a better allocation of time between work and leisure. The choice to work the extra 8 hours per week under the fixed tax indicates that he or she prefers 50 hours of work per week with a net income of $229 to 42 hours of work and a weekly gross income of $210 (net, $189). The inability to achieve this preferred position with an income tax is an indication of the excess burden of that tax.

Equitability in Taxation. The principle of horizontal equity is widely accepted as a desirable feature of a tax. Stated simply, this principle requires that equals be treated equally. Generally, some measure of economic capacity or well-being has been sought as the relevant index of equality for tax purposes.

A corollary to the principle that equals be treated equally is the principle of vertical equity, which suggests that unequals be treated unequally. According to this principle, individuals should be taxed in accordance with their ability to pay. Unfortunately, although the ability-to-pay principle usually requires that taxpayers with greater economic capacity pay a greater share of total tax burden, it is a subjective standard and does not provide clear guidelines with respect to the precise allocation of tax shares. A proportional, a progressive, or even, within limits, a regressive income tax, for example, can collect more in total tax revenue from the rich person than from the poor person.

One justification for progressive taxation is a desire to use the tax system to reduce inequality in the distribution of income. The extent to which the tax system can and should be used in this way is an important issue in tax policy. There are two types of progressive taxes. A degressive tax exempts some initial amount of the base from taxation and subjects all of the base in excess of this amount to a single flat rate. A graduated-rate progressive tax, on the other hand, subjects increments in the base to successively higher marginal rates—the marginal tax rate being the increment in tax liability divided by the increment in tax base. With respect to a personal tax such as the income tax, the minimal amount of progressivity embodied in the degressive tax is relatively uncontroversial. The initial exemption protects the poorest members of the society from tax burden. The issue of whether and to what degree a tax system ought to move beyond this minimal progressivity, however, is a subject of ongoing debate.

The ability-to-pay principle deals only with the allocation of a predetermined aggregate tax burden and thus fails to link the tax and expenditure sides of the public budget. An alternative tax principle that remedies this problem is the benefit principle of taxation. Under the benefit principle, an individual's tax burden is based on the benefits that he or she receives from public services. The benefit principle is, in most instances, difficult to follow with great precision because of difficulties with actually measuring individual benefits from public services and because the people who most need services are often those least able to pay.

See also: ECONOMY, NATIONAL; INCOME, NATIONAL; SINGLE TAX.

taxidermy Taxidermy is the art of preparing, preserving, and mounting the skin, hair, feathers, or scales of animals in a lifelike position for study or display. The word *taxidermy* is derived from the Greek *taxis*, "to arrange," and *derma*, "skin." Taxidermy is used to mount hunting and fishing trophies, and many natural history museums have taxidermists on their staffs to prepare animal specimens for display.

Early cultures practiced a form of taxidermy in the preparing of skins and other parts of animals for clothing, ornamentation, or ritualistic accoutrements. Writings and existing specimens show that taxidermy, as it is known today, was practiced at least as early as the 16th century. The methods in current use, however, began in the late 19th century.

Techniques vary with the kind of animal, but in all cases the skin is removed, cleaned, chemically treated with a preservative, and placed on a prepared model made of a stable, strong material that will withstand insects and changes in humidity and temperature. The model is sculptured to reproduce the exact size and shape of the specimen and can be made from a material such as balsa wood, laminated paper, wire mesh with papier-mâché, foam plastic, or fiberglass. Treated fish skin is mounted over a mold made from the fish before it was skinned. Fish, reptile, and amphibian skins tend to lose color and must be painted after mounting.

taxonomy see CLASSIFICATION, BIOLOGICAL

Tay, River [tay] The River Tay—Scotland's longest, at 188 km (117 mi)—rises in the Grampian Mountains in two headstreams, the Lochay and Dochart, which join at Loch Tay. The river then flows past Perth and Dundee to the 40-km-long (25-mi) Firth (estuary) of Tay on the North Sea. The firth is crossed by railway (1888) and road (1966) bridges; the original railway bridge collapsed during a storm in 1879.

Tay-Sachs disease [tay-saks] Tay-Sachs disease is a rare GENETIC DISEASE in which the lack of an enzyme (hexosaminidase A) involved in the metabolism of brain lipids causes a fatty substance called ganglioside to accumulate in nerve cells of the brain. The disease develops during infancy, primarily in babies of Jewish descent, and leads to blindness, dementia, convulsions, extensive paralysis, and death, usually in 2 to 4 years. The Tay-Sachs gene, which is carried by 4 percent of American Jews of European extraction, must be present in both parents for the child to develop the disease. A medical procedure called AMNIOCENTESIS allows detection of the disease before birth.

Taylor, Cecil The pianist and composer Cecil Percival Taylor, b. New York City, Mar. 15, 1933, a leader in experimental jazz, has always had more influence than fame. Taylor's jazz style owes much to Béla Bartók and Igor Stravinsky. His long works have pointed toward new musical paths and earned the admiration of the international jazz community but have proved too demanding for a wider audience. In addition to composing and performing, Taylor has taught at several universities.

Taylor, Edward An outstanding poet of colonial America, Edward Taylor, b. near Coventry, England, 1642, d. June 24, 1729, went to New England in 1668 and, after graduation (1671) from Harvard, accepted what was to be a lifelong ministry at Westfield, Mass. There, despite arduous duties, he found time to write more than 200 "Preparatory Meditations" (1682–1725) and several longer poems, including the Calvinist "God's Determinations Touching His Elect" (*c.*1682). Taylor's books and manuscripts passed to the Yale library in 1883, but his poems were not published until 1939.

Taylor, Elizabeth A violet-eyed English beauty, film actress Elizabeth Taylor, b. London, Feb. 27, 1932, was catapulted to stardom while still a child by her fourth Hollywood movie, *National Velvet* (1944). Although subsequently as celebrated for her glamorous personal life and numerous marriages—most notably to actor Richard Burton—as for her acting ability, she gave creditable performances in *A Place in the Sun* (1951), *Cat on a Hot Tin Roof* (1958), *Suddenly, Last Summer* (1959), *Butterfield 8* (1960), and *Who's Afraid of Virginia Woolf?* (1966). For the last two she won Academy Awards. She has appeared on Broadway (1981; 1983), and also occasionally on television.

Elizabeth Taylor, in one of her finest performances, played Martha opposite Richard Burton's George in the film version of Who's Afraid of Virginia Woolf? *(1966).*

Taylor, Frederick Winslow The U.S. inventor and engineer Frederick Winslow Taylor, b. Philadelphia, Mar. 20, 1856, d. Mar. 21, 1915, is known as the "father of scientific management." He started working at the age of 18 as an apprentice pattern maker and machinist in Philadelphia. In 1881, Taylor began to study how individual tasks were being performed at the mill. He timed each task and then greatly increased individual productivity on the job by rearranging work stations and the flow of materials through the mill. Thus began the first time and motion studies that made Taylor famous. His *Principles of Scientific Management* (1911) is a classic in industrial psychology.

Taylor, Jeremy Jeremy Taylor, b. Aug. 15, 1613, d. Aug. 13, 1667, was an English bishop and devotional writer. After the royalist defeat in the civil war, he was deprived of his parish (1644) and became private chaplain to the 2d earl of Carbery in Wales. There Taylor produced his classic, *Rule and Exercises of Holy Living* (1650), and . . . *of Holy Dying* (1651).

Taylor, Maxwell D. The American general Maxwell Davenport Taylor, b. Keytesville, Mo., Aug. 26, 1901, d. Apr. 19, 1987, had a long and notable military career and served (1964–65) as U.S. ambassador to South Vietnam. During World War II he helped organize the 82d Division (the first U.S. airborne division). At considerable risk, he infiltrated Axis lines before the Allied invasion of Italy in 1943 to confer in Rome with Italian officials. In 1944, commanding the 101st Airborne Division, Taylor participated in the assault on Normandy in June and later, with his unit, landed from the air in the Netherlands. He led the United Nations Eighth Army near the end of the Korean War. As army chief of staff (1955–59) and chairman of the joint chiefs of staff (1962–64), Taylor pressed for greater stress on balanced conventional forces. While ambassador to South Vietnam he backed substantial escalation of U.S. involvement.

Taylor, Paul The dancer and choreographer Paul Taylor, b. Pittsburgh, Pa., July 29, 1930, is one of the masters of modern American theater dance (see MODERN DANCE). He performed with the companies of Pearl Lang and Merce Cunningham in 1953. From the mid-1950s to the early 1960s, Taylor danced many principal roles in the Martha Graham Company. At the same time he presented his experimental choreography in pieces like *Epic* (1957), in which he wore a business suit and performed everyday gestures to recorded time signals. In 1961 he began to devote himself entirely to his own company and presented *Insects and Heroes* to general acclaim. Since then, he has choreographed many such characteristic works, blending contemporary elements—broad humor and simplified movements—with traditional aspects of dance: the use of classical music accompaniment and a concern with form.

Taylor, Peter Peter Matthew Hillsman Taylor, b. Trenton, Tenn., Jan. 8, 1917, is a distinguished American fiction writer. A distinctly Southern author, Taylor chooses to express his ironic perception of social change through descriptions of small-town life in Tennessee. His writing is regional but far from parochial: his psychologically complex works delve beneath and beyond his literal settings to disclose the universal yearnings of the human heart. Though mostly a short-story writer—his collections include *Miss Leonora When Last Seen* (1963), *In the Miro District* (1977), *The Old Forest* (1985), and *The Collected Stories* (1986)—Taylor has also written novels and plays. His novel *A Summons to Memphis* (1986) won the Pulitzer Prize.

Taylor, Zachary Zachary Taylor was a military leader and the 12th president of the United States (1849–50).

Early Life and Career. Taylor was born in Orange County, Va., on Nov. 24, 1784. Raised on the Kentucky frontier, he joined the army in 1808 and distinguished himself in the defense of Fort Harrison against the Indians during the War of 1812, rising to the rank of major. From 1816 to 1832 he served at various frontier posts. Promoted (1832) to colonel, he led the First Infantry Regiment in the Black Hawk War. He participated (1837–38) in the Seminole Wars, winning promotion to brigadier general as well as the nickname Old Rough and Ready. In 1845, President James K. Polk ordered Taylor to occupy the Republic of Texas after its annexation by the United States and to defend it against a threatened Mexican invasion.

Mexican War. The government of Mexico was taken over in December 1845 by radical Mexican Centralists who regarded the annexation of Texas as an act of war and Taylor's military occupation of Texas as an invasion of Mexican territory. After the failure of a U.S. peace initiative, Polk ordered Taylor to move his forces south to the Rio Grande. The general did so in March 1846, amid increasing threats of hostility from the Mexican Centralists. The Mexican War began on April 25, after Mexican troops had crossed the Rio Grande and attacked an American detachment. Additional Mexican attacks followed at Palo Alto (May 8) and Resaca de la Palma (May 9), but Taylor won unexpected victories that were responsible, in part, for the overthrow of Mexico's Centralist government.

On May 13 the United States declared war; shortly thereafter, Taylor was voted a gold medal and promoted to major general (June 29, 1846). More important, perhaps, he captured the popular fancy and was mentioned as a possible 1848 presidential candidate. His military decisions for the rest of the Mexican campaign, however, have been criticized. Plagued by inefficient logistical support, raw and untrained recruits, and inadequate transportation, Taylor was slow to occupy Matamoros and thus gave the enemy a chance to withdraw. He did not pursue the fleeing Mexican army southward but began a movement up the Rio Grande. By August he had reached Camargo and besieged Monterrey, Mexico's largest community, which fell on September 24. Lacking supplies, Taylor—in what may have been his greatest military blunder—granted an 8-week armistice to the Mexican commander, Gen. Pedro de Ampudia, allowing him to withdraw southward still in possession of most of his arms and ammunition.

Polk criticized Taylor severely, ordering him to release most of his troops to Gen. Winfield SCOTT and take a defensive position. Taylor, however, occupied Saltillo, the capital of Coahuila in northern Mexico. Polk, hoping to arrange an armistice, allowed Mexican dictator Antonio López de SANTA ANNA safe passage through the U.S. blockade at Veracruz. At Buena Vista, Santa Anna attacked Taylor, who won a surprise victory.

AT A GLANCE

ZACHARY TAYLOR
12th President of the United States (1849–50)

Nickname: "Old Rough and Ready"

Born: Nov. 24, 1784, near Barboursville, Va.

Profession: Soldier

Religious Affiliation: Episcopalian

Marriage: June 21, 1810, to Margaret Mackall Smith (1788–1852)

Children: Ann Mackall Taylor (1811–75); Sarah Knox Taylor (1814–35); Octavia P. Taylor (1816–20); Margaret Smith Taylor (1819–20); Mary Elizabeth Taylor (1824–1909); Richard Taylor (1826–79)

Political Affiliation: Whig

Writings: *Letters of Zachary Taylor* (1908)

Died: July 9, 1850, Washington, D.C.

Buried: Zachary Taylor National Cemetery, near Louisville, Ky.

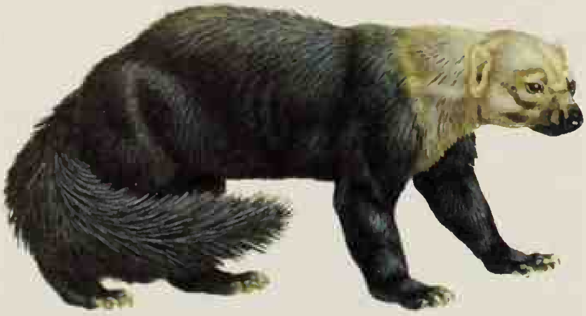
Vice-President: Millard Fillmore

Z. Taylor

Presidency. Taylor's popularity as a military hero enabled him to win the Whig nomination for the presidency, with Millard FILLMORE as his running mate. In the November election—a three-way contest in which he faced Democrat Lewis Cass and Free Soiler Martin Van Buren—Taylor won 15 of the then 30 states and a plurality of the popular vote.

During his brief term (Mar. 5, 1849–July 9, 1850), Taylor presided over the ratification of the Clayton-Bulwer Treaty and the near secession of the South over the issue of slavery in the territory newly acquired from Mexico. A supporter of the WILMOT PROVISO (1846), which stipulated that the Mexican Cession should be closed to slavery, Taylor encouraged both New Mexico and California to apply for admission as free states. He further angered his Southern followers by ignoring the claims of Texas—a slave state—to territory assigned to New Mexico. The COMPROMISE OF 1850 prevented Southern secession for the time being, although it did not pass Congress until after Taylor's death. The president died on July 9, 1850, of cholera. Vice-President Fillmore succeeded him.

tayra [ty'-ruh] The tayra, *Tayra barbara*, in the weasel family, Mustelidae, is a slender-bodied, agile animal found in forests from southern Mexico to Argentina. It is about 63 cm (25 in) long, plus a 45-cm (18-in) tail, and typically has a dark brownish coat and a lighter head and chest patch.



The tayra is a small, omnivorous mammal found in wooded areas of Central and South America. A member of the weasel family, it has a slim body, short legs, and a long tail.

Tayside [tay'-syd] Tayside is an administrative region in east central Scotland, with an area of 7,643 km^2 (2,951 mi^2) and a population of 393,700 (1988 est.). The region slopes from western hills to the North Sea coast in the east. The major cities are Dundee and Perth. The economy is based on the manufacture of linens and woolens, distilling, sheep raising, shipbuilding, and tourism at the coastal resort towns. Tayside was constituted during the 1975 reorganization of local government in Scotland from the former counties of Angus, Kinross, and most of Perth.

Tbilisi [tuh-bil'-ee-see] Tbilisi, formerly Tiflis, is the capital of Georgia, a republic of the USSR, located in Transcaucasia. The city's population is 1,260,000 (1989). The name *Tbilisi* derives from a Georgian word meaning "warm," reflecting the presence of hot sulfur springs.

Tbilisi is a manufacturing and transportation center at the junction of railroads and highways. It is the southern terminus of the Georgian Military Highway across the Caucasus Mountains. Tbilisi's industries include the manufacture of electric locomotives, machine tools, and electrical-engineering products. Textile, paper, and apparel manufacturing, liquor distilling, and food processing are also important.

The city's location on the Kura River, hemmed in by the Surami Range, has given Tbilisi an elongated shape, extending 27 km (17 mi) along the river. Historical sites include the ruins of the ancient fortress Narikala, the 13th-century Metekhi castle and cathedral, the 5th-century Sioni Cathedral, and the 6th-century Anchikhati Cathedral. The Georgian Academy of Sciences (founded in 1941), a university (1918), a conservatory, an art academy, and theaters are in the city. On Mtatsminda Hill is a pantheon, containing the graves of prominent Georgian cultural figures.

The existence of a fortress on the site of Tbilisi was first reported in the 4th century. Georgia's capital since the 11th century, Tbilisi grew more rapidly after Georgia's union with Russia in the early 19th century.

TBT see TRIBUTYL TIN

Tchaikovsky, Peter Ilich [chy-kawf'-skee] The eminent Russian composer Peter Ilich Tchaikovsky was born on May 7 (N.S.), 1840, in a settlement adjacent to the Kama-Votkinsk Metal Works (managed by his father) in the Ural Mountains. From 1850 to 1859 he attended the School of Jurisprudence in Saint Petersburg, where he assisted in a choir and studied piano and harmony. Assigned on graduation to the Ministry of Justice, Tchaikovsky continued to be drawn to music. In 1862 he left his job and entered the just-founded Saint Petersburg Conservatory. Working zealously under Anton Rubinstein and Nikolai Zaremba, he received a silver medal for his graduation cantata in December 1865.

At Nikolai Rubinstein's invitation, Tchaikovsky taught theory in Moscow, joining the faculty of the new Moscow Conservatory when it opened in September 1866. During his 11 years there, he composed his Piano Concerto No. 1 (1875), the ballet *Swan Lake* (1876), four operas, three symphonies, and many smaller works. He also established close ties with the composers of the nationalist group known as "The Five," especially Mily Balakirev and Nikolai Rimsky-Korsakov.

Peter Ilich Tchaikovsky, probably the most popular 19th-century Russian composer, was also the first to have a formal musical education. By 1874, when this photograph was taken, the composer was 34 years old and had already composed, among many other works, three of his ten operas, the first two of his six symphonies, and the Romeo and Juliet *Overture-Fantasy.*

Marriage in July 1877 to Antonina Miliukova triggered an emotional crisis, perhaps related to his homosexuality, that brought him near suicide. He fled Moscow in a state of turmoil but managed to finish three masterpieces—the Fourth Symphony, the Violin Concerto, and the opera *Eugene Onegin*—before May 1878, when his wife agreed to separation (they were never divorced). An annuity from Nadezhda von Meck, granted during his crisis, allowed him to quit (1878) teaching. His association with von Meck, begun in an exchange of letters about a commission in 1876, was sustained in voluminous correspondence over 13 years, although they never met. From 1878 to 1885, Tchaikovsky lived sometimes in Russia, sometimes in western Europe. His reputation grew with the *Capriccio italien* (1880), the *1812* overture (1880), two more operas, the *Liturgy* (1878), and the *Vespers* (1881). During his last years he lived in or near Moscow. In 1888, Tsar Alexander III granted him a yearly pension.

Tchaikovsky's fame, as both conductor and composer, spread as the result of a series of international tours, which brought him to the United States in 1891. He continued to compose—the ballets *Sleeping Beauty* (1889) and *Nutcracker* (1892), the Fifth (1888), Sixth (1893), and *Manfred* (1885) symphonies, and three final operas. Younger composers emulated him, among them Sergei Taneyev, Anton Arensky, Mikhail Ippolitov-Ivanov, and, later, Sergei Rachmaninoff. A few days after conducting the premiere of his Sixth Symphony, he contracted cholera and died in Saint Petersburg on Nov. 6 (N.S.), 1893.

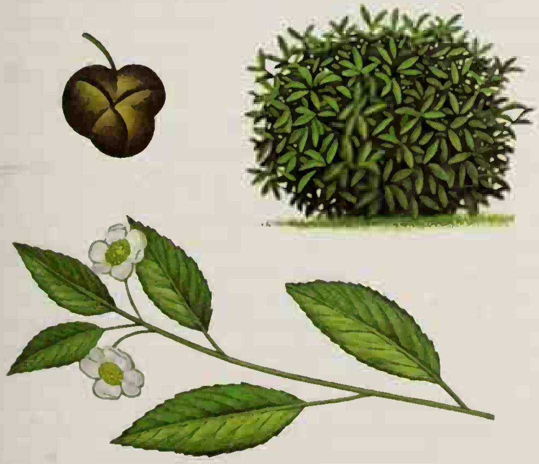
Although Mozart was his most beloved composer, Tchaikovsky owes much of his lyric gift to Russian folk song, which he quotes (First Piano Concerto, Second and Fourth symphonies) or imitates (First Symphony, Second String Quartet), and to the 19th-century Russian salon song, whose traits permeate his vocal melody (songs and romances, *Eugene Onegin*) and even infuse his instrumental themes (Fifth and Sixth symphonies).

Tchelitchew, Pavel [chay-lee'-chef] The neoromantic artist Pavel Tchelitchew, b. Moscow, Sept. 21 (N.S.), 1898, d. July 31, 1957, is best known for his tormented metamorphic paintings and his imaginative ballet designs. His paintings of the 1920s show strong surrealist elements, with fantastic distortions of everyday objects. After his move to the United States in 1934, Tchelitchew began the sketches for his major painting, *Hide-and-Seek (Cache-Cache)* (1940–42; Museum of Modern Art, New York City), a nightmarish vision of infant heads and internal and external organs enmeshed in skeins of blood vessels.

Te Kanawa, Kiri Kiri Te Kanawa, b. Gisborne, New Zealand, Mar. 6, 1944, is an internationally renowned opera singer who in 1982 was made a Dame of the British Empire. A soprano, she won numerous singing competitions in New Zealand and Australia prior to becoming a student at the London Opera Centre. She began an association with the Royal Opera Company, Covent Garden, in 1970, achieving (1971) her first major success as the countess in Mozart's *Marriage of Figaro*. In 1974 she made her New York Metropolitan Opera debut in Verdi's *Otello*.

tea Tea is the beverage made when the processed leaves of the tea plant are infused with boiling water. Native to Southeast Asia, the tea plant, *Camellia sinensis*, is a small, shrublike, evergreen tree that belongs to the family Theaceae; its seeds contain a volatile oil, and its leaves have the chemicals CAFFEINE and tannin. The dark green leaves are elliptical in shape and have serrated edges, and the plant produces aromatic, white blossoms. Although second to coffee in commercial value, tea is the world's most popular beverage.

Tea is a shrub with abundant foliage, camellialike flowers, and berries containing one to three seeds. The beverage made from leaves of the tea plant is among the world's most popular drinks.



Tea leaves are harvested on a plantation in Darjeeling, India. Located in the Himalyan foothills, Darjeeling has a high altitude and rainfall conducive to tea cultivation. The crop from Darjeeling has made India a leading producer of tea.

History. The origins of tea culture and the brewing of tea leaves are obscure. According to Chinese legend, the emperor Shennong learned how to brew the beverage in 2737 BC when a few leaves from the plant accidentally fell into water he was boiling. Tea leaves began to be processed and sold. Lu Yu's *The Classic of Tea*, published in China in AD 780, described the cultivation, processing, and use of tea. Tea was introduced by Chinese Buddhist monks into Japan, and tea culture then spread to other tropical and subtropical areas. British merchants formed the East India Company (1600–1858) and introduced teas into England and the American colonies.

Cultivation. Tea plants are grown on tea plantations, called gardens or estates, in areas that have a great amount of rainfall and rich, loamy soil.

Tea-plant seeds are planted in a nursery, and when the young trees are between 6 and 18 months old, they are replanted in the garden. Nowadays, however, plants are frequently cloned. The tea plants are pruned periodically in order to maintain a height of about 1 m (3 ft) and to encourage the growth of new leaves. Plants grown at low altitudes produce leaves for commercial use after 2½ years, and those grown at high altitudes are ready in 5 years. The best leaves are produced at altitudes of 1,000 to 2,200 m (3,000 to 7,000 ft).

Processing. The leaves are hand plucked. Only the smallest, youngest leaves are used to produce tea. The three main types of tea being produced today are black (fermented), oolong (semifermented), and green (unfermented).

To make black tea, harvested leaves are first dried. They are then roller crushed to break the cell walls and release an enzyme. This process gives the tea its flavor. The leaves are spread in a fermentation room to oxidize, which turns them to a copper color. They are finally hot-air dried; this stops fermentation and turns the leaves black. The tea is then sieved and graded. Leaf-grade sizes run from pekoe, the coarsest size, to flowery orange pekoe, the smallest. Tippy golden flowery orange pekoe designates a tea containing the golden-colored tip. Broken teas are those having leaves broken during processing.

The tea plant found in Taiwan and south China appears to be most suitable for preparing oolong tea. The process begins in the same manner as that for black tea. The aroma, however, develops more quickly, and when the leaf is fired or dried, a coppery color forms around the edge of the leaf while the center remains green. The oolong flavor is fruity and pungent.

Green tea is heated before rolling, to destroy the enzyme. The leaf then remains green throughout further manufacture and the aroma characteristic of black tea does not develop. Gunpowder and young hyson are types of green tea.

Unblended and Blended Varieties. Among the unblended teas are Assam and Darjeeling, produced in India; Ceylon teas, which have a smooth, flowery flavor; and Keemun, a China black tea also known as English Breakfast tea. Among the more popular blended teas are Irish Breakfast (high-grown Ceylon and Assam teas); Russian style, which is a China Congou sometimes containing other teas or scents; and Earl Grey, a black tea flavored with bergamot or lavender oil.

World Production. India, China, Sri Lanka (Ceylon), Japan, Indonesia, Kenya, and regions of the USSR (Georgia and Azerbaijan) are the world's leading tea producers.

tea ceremony The Japanese tea ceremony, or *cha-no-yu*, is the ancient practice of serving tea according to a strict ritual that defines the manner in which tea is prepared and served. Rooted in ZEN BUDDHISM, the art of the tea ceremony symbolizes aesthetic simplicity through the elimination of the unnecessary.

The traditional ceremony, as practiced today, takes place in a tea room, or *cha-shitsu*, situated in a garden or a special room within a house. The simply constructed room is small, accommodating a host and five guests, and the floors are covered with straw (tatami) mats. The most formal ceremony takes four hours, and two types of green tea are served. A gong is sounded to signal the beginning of the ceremony. Following a prescribed pattern, the host prepares the tea with the utmost exactness. The principal guest is served first, after which the ritual is repeated. The accurate and delicate performance of each act is thought to represent the fundamental Zen principles of harmony, respect, purity, and tranquility.

The tea ceremony was originated in China by Buddhist monks who believed that tea had medicinal qualities. It was brought to Japan in the 13th century.

Teach, Edward see BLACKBEARD

teacher education see TEACHING

Teachers College, Columbia University Established in 1887, Teachers College is the graduate school of education of Columbia University in New York City. Master's degrees and doctorates are granted in all programs, which are concerned with teacher education and educational administration.

teaching Teaching is the purposeful imparting of information or skills or both to another individual or to a group. The concept of teaching can be broadened to include textbooks, computers, or educational television. Whatever technologies are used as aids in instruction, however, it is the human teacher who makes the decisions concerning the content and the means by which instruction is delivered.

The range of classroom teachers includes preschool, elementary, secondary, and higher-education teachers, as well as teachers in industry and teachers of teachers. Teaching can impart information about how to ride a bike, how to fill in an employment form, or how to interpret a passage from Shakespeare. The number of individuals involved in teaching far exceeds that in any other profession.

There are several essential requirements for teachers: whatever the subject, they must know the material they are to teach; they must be able to organize and articulate the material in a manner understandable to the students; and they must manage the students in order to maintain student attention on the learning task.

Career Conditions and Teacher Education

In the United States, as elsewhere, teaching traditionally has been an occupation that does not receive adequate support. Salaries are low: in the United States, beginning salaries of teachers, adjusted for 12 months, are lower than those for any other field requiring a bachelor's degree, and they top out sooner and at a lower level than other college-degree-level occupations. Classrooms are often crowded, materials and supplies outdated or nonexistent, and in certain schools and locales teachers are threatened with physical violence. Public esteem for teachers and schools is low, although parents of children in school are happier with the schools than is the general public.

With few exceptions around the world (Japan being one), teaching at the precollege level has for some time been a female occupation. Some writers, including the pioneer U.S. feminist Susan B. Anthony, have suggested that the lower-than-deserved status and salaries of teachers are additional instances of discrimination against women. Teaching, consequently, was not an occupation that one stayed in year after year. Some women quit to get married and have children; others left to pursue more lucrative occupations. At present, school districts are having especial difficulty attracting and retaining math and science teachers because the salaries in related occupations, such as computer programming, are luring prospective and practicing teachers away from education.

Current teacher shortages may, however, allow the profession to catch up on pay. New Jersey in 1985 became the first state to adopt a state-wide minimum for teachers' salaries.

Associations of and for Teachers. The low salaries and poor conditions associated with teaching created the ideal atmosphere for the formation of teachers' associations designed to work for the establishment and protection of employment rights for teachers, and to improve salaries and other conditions. Two rival organizations sprang up in the United States. The National Education Association (NEA), founded in 1857, is a loosely organized group of local, state, and national organizations that includes both administrators and teachers in its membership. Many teachers viewed the involvement of both teachers and administrators in the NEA as conflict of interest; administrators who make decisions about teachers' salaries might not be willing to work for increasing them. The American Federation of Teachers (AFT), a teacher-only labor union formed in 1916, fought for the right to create bargaining units in school districts. The AFT unabashedly works to obtain higher salaries and better conditions for teachers, and the organization calls strikes when necessary. As administrators began forming their own associations (such as the American Association of School Administrators) and as teachers began to dominate the organizations, the NEA moved closer to the AFT in its demands and in its attitude toward strikes.

Numerous education associations in the United States lobby for their members' rights and interests. Teacher educators, for example, have the American Association of Colleges for Teacher Education and the Association of Teacher Educators; vocational educators have several, as do speech and hearing therapists, teachers of mathematics, and school volunteers. College professors have the American Association of University Professors. At times these organizations press for policies that conflict with the interests of the AFT and NEA.

Teacher Preparation. During the 19th century there were few state or local regulations concerning the education level prerequisite to becoming a teacher. Often, when a student finished a grade level, she or he turned around and taught it the next year. Few teacher training institutions existed, and those which did were often at the level of secondary schools. From 1900 on, during the period of such influential theorists as John Dewey and Edward L. Thorndike, teacher education was steadily lengthened and improved to the point that four-year, degree-granting programs, specializing in teaching, were established. These normal schools were initially designed for prospective secondary teachers, requirements for whom exceeded those for elementary teachers. In the United States, state legislation gradually began to mandate the educational requirements for becoming a teacher. In 1946, 20 states mandated a bachelor's degree for elementary teaching; by the 1970s, all states required the degree. By the mid-1980s, about half of all U.S. elementary and secondary teachers held degrees beyond the bachelor's.

Most teacher-preparation programs consist of subject-matter and general liberal-arts courses, as well as specialized pedagogical courses. In some places a student is expected to earn a B.A. degree before entering the teacher-education program. More generally, the prospective teacher receives a B.A. in teaching. There is an inherent tension between the academic and pedagogical requirements. Some recent reform proposals suggest that teachers should take more subject-matter courses and skip the pedagogical courses. Others argue that prospective teachers should spend more time gaining practical teaching experience before entering the profession.

Pedagogical programs are remarkably similar around the world. Methods courses prepare students to teach specific subject-matter areas; courses in teaching and learning specialize in generic teaching skills, learning theory, and assessment theory; foundations courses prepare students for the intellectual, social, and cultural settings in which schooling takes place, and practice teaching provides students with supervised teaching experience in the classroom.

In the United States approximately 40% of a prospective secondary school teacher's college preparation is devoted to general liberal-arts education, 40% to the specific subject-matter area she or he is going to teach, and 20% to professional studies. The figures for elementary education are: 40% in general liberal arts, 15% in other liberal arts, and 45% in professional studies.

In most countries the national government controls the accreditation of teacher-education institutions and the certification of graduates. In the United States the states control the certification of the graduates, but not all states control accreditation. Instead, an independent, nongovernmental national association provides accreditation to those institutions which apply for and pass the review. The National Council for Accreditation of Teacher

A prerecorded lecture is presented by videotape to a high school class in Utulei, in Western Samoa. The use of taped and broadcast educational television programs is central to education in many developing countries.

Education (NCATE) cannot require an institution to submit to a review, but its member institutions graduate 87% of school personnel.

Recent concern with the quality of U.S. teacher education has led to the idea of requiring a fifth or sixth year, or a master's degree in teacher education, in which students would enter the teacher-education program only after receiving their bachelor's degree. Another idea is that of continuing supervisory support for teachers into the first several years of teaching, variously called internship or beginning teacher programs.

Teaching Methods and Aids

Teaching is a highly complex occupation involving a variety of roles. For example, teachers are executives, supervising students and planning programs within the workplace. Teachers manage time, material, knowledge, and students. They are expert communicators with their students as well as with parents and other adults within the school, and they are decision makers, making numerous decisions in one class period, often simultaneously and "on their feet." They must also perform as lunchroom and school-bus monitors and as file clerks.

In their basic role as instructors, teachers use a number of methods to involve their students in the content of the curriculum. The most popular, by far, is the lecture technique. Excluding lab periods, approximately 90% of college teaching is by the lecture method. The figure is somewhat lower at the secondary level, and lower still in primary-school classrooms. Secondary teachers also rely extensively on seatwork, during which students work at their desks on an assignment and teachers circulate to answer questions or sit at their own desks and correct the students' work. Many teachers in secondary and some postsecondary classes use discussion sessions to stimulate their students' interest and to assess their grasp of the material. Discussion sessions go beyond the usual question-and-answer sequences that accompany lectures in that they are meant to help students extend their knowledge through higher-level thinking.

Students in a language laboratory can listen to recorded lessons selected by the teacher. They can also record their own efforts to speak the language and receive individual instruction from the teacher at the console.

Computers are multiplying in the schools, although debate continues as to their most efficient use. Many programs simply review classroom learning. More ambitious is the "discovery learning" approach, encouraging active experimentation.

Grouping of students within the classroom occurs primarily at the elementary level. For example, most early elementary reading teachers place their students in two to three groups based on the pupils' achievement levels, which enables the teacher to work more easily with them. Grouping can serve other purposes too. Cooperative learning groups, for example, place students of different abilities in the same group, and the students within that group tutor each other on assignments. These programs are effective in raising students' achievement levels as well as in improving their social skills and attitudes toward one another.

Another method that is increasing in popularity is the use of simulations, particularly for adults learning different types of skills. Simulations attempt to create conditions as close to the real situation in which the individual will be performing the skill as possible. For example, some teacher-education programs include sequences in which one student teaches a lesson to his or her fellow students who are posing as elementary or secondary students. Airline pilots log many hours on flight simulators, and driver-education courses are beginning to involve simulation computer work.

Until recently the use of technology in primary and secondary teaching has been minimal, usually limited to basic equipment for science labs and sewing machines and ovens for home-economics courses. Use of the overhead projector, an example of an audiovisual teaching aid, has increased, but it is still not a standard item in most classrooms. Innovations such as educational television and TEACHING MACHINES have often ended up in dusty school closets. (See also PROGRAMMED LEARNING.)

One exception appears to be the computer, although it is not yet clear whether school computers will end up in a special room called a computer lab or in the classroom.

Initially, computers were used to provide students with extra practice in subjects such as math. Called computer-assisted instruction (CAI), these programs appeal to students and do at least as well as teacher instruction in raising student achievement.

Computers are also used in helping students to learn writing skills, and some computer programs actually teach students a new skill or body of knowledge. Many of the programs are in the form of games to help motivate students. It is unclear, however, whether the students actually learn skills beyond performing the game, or the degree to which teachers must be involved in the process to ensure that students learn what is intended.

The major problems with computers in the schools are that extensive staff development is required to help teachers learn to use the computers, and that the software has not kept up with the capacity of the machines or the interests of the students. Many programs are simply electronic page-turners.

See also: CURRICULUM; EDUCATION; PRESCHOOL EDUCATION; PRIMARY EDUCATION; SECONDARY EDUCATION; UNITED STATES, EDUCATION IN THE.

teaching machines Teaching machines, used in PROGRAMMED LEARNING, are devices that are able to store instructional information, present displays selected from this information, receive responses from a learner, and act on those responses in order to generate new data and displays. They can be divided into four classes, according to whether they involve print media, audiovisual media, manipulated objects, or computers.

Sidney L. Pressey is usually given credit for developing the first teaching machine in the 1920s. The idea received major impetus during the 1950s from the work of B. F. SKINNER. Self-instruction programs written according to Skinner's methods were often administered by means of a machine that presented a graded series of questions, each requiring a written response. The machine kept the correct answer hidden until after receiving the student's answer.

This McDonnell Douglas flight simulator, used to train pilots on the ground, is a computer-controlled teaching machine. Cockpit controls and instrumentation respond to the pilot's movements, flight motion is simulated, and a visual representation is projected in front of the cockpit window.

Audiovisual media include audiotapes, filmstrips, color slides, motion pictures, and videotapes. To be considered a teaching machine, audiovisual devices must present different displays depending on responses from a learner. A cockpit simulator in which a pilot trainee can move the controls and observe simulated displays on instruments is an example of a teaching machine employing manipulated objects.

A computer-based teaching machine is a computer-controlled television display on which color images, some accompanied by audio and some in motion, can be displayed depending on choices made by the user. Students use a typewriterlike keyboard to enter their responses.

Teague, Walter D. [teeg] Walter Dorwin Teague, b. Decatur, Ind., Dec. 18, 1883, d. Dec. 5, 1960, was one of the earliest industrial designers who, along with Henry Dreyfuss and Raymond Loewy, helped establish INDUSTRIAL DESIGN as a separate discipline and a recognized profession. Teague studied at the Art Students League of New York from 1903 to 1907, then worked as an artist and designer and, in 1926, designed the Kodak Baby Brownie, a simple, functional, and highly successful camera that established Teague's reputation as an industrial designer. The design assignments that followed included automobiles, service stations, railway equipment, airplane interiors, household and heating appliances, business machines, machine tools, offices, showrooms, department stores, and furniture.

teak Teak, *Tectona grandis*, family Verbenaceae, is native to India, Burma, and Thailand. The tree grows to a height of 46 m (150 ft) and has a straight, often buttressed trunk and a spreading crown. The large, drooping leaves, opposite or occasionally whorled on the four-sided branches, grow to 30 cm (1 ft) in length and 5–30 cm (2–12 in) in width. The foliage is covered with hairs beneath. The white flowers are small and numerous, and the fruit is a drupe. Trees have gray bark, white sapwood, and a yellow to brown aromatic heartwood that retains its fragrance for years.

Since ancient times teak has been one of the world's most valuable timber trees. The wood is easily worked and well noted for its resistance to decay. Teakwood is used for ships, wharves, and bridges as well as for fine furniture, venetian blinds, and veneer. The term teak also refers specifically to the wood and its characteristic color, which ranges from olive to yellowish gray or moderate brown.

Rhodesian teak comes from *Baikiaea plurijuga* of the family Leguminosae and is native to Angola, Zambia, and Zimbabwe. Its lumber is also valuable and is used especially for flooring.

Teamsters, Chauffeurs, Warehousemen, and Helpers of America, International Brotherhood of The International Brotherhood of Teamsters, Chauffeurs, Warehousemen, and Helpers of America (1903) is a labor union that represents truck drivers and workers in a variety of industries. Team drivers were organized as an American Federation of Labor affiliate in 1899. Troubled from the start by corruption and alleged links to organized crime, the Teamsters nevertheless grew to become the largest union in the United States, with almost 2 million members in the late 1980s. The investigations of the McClellan Committee in 1957 led to the conviction of Teamsters president Dave Beck and the expulsion of the Teamsters from the AFL-CIO. Beck was replaced by James R. HOFFA, who was imprisoned in 1967 for jury tampering and fraud. Other presidents were Frank Fitzsimmons (1971–81), Roy Williams (1981–83), and Jackie Presser (1983–88). During their presidencies, Williams was convicted of bribery and Presser was under indictment on racketeering charges. William J. McCarthy became president in 1988, following Presser's death. In 1987 the Teamsters rejoined the AFL-CIO.

Teapot Dome Teapot Dome, near Caspar, Wyo., was a federally owned oil reserve involved, with the reserve at Elk Hills, Calif., in a scandal associated with the administration of U.S. president Warren G. HARDING. Teapot Dome subsequently became a symbol of scandal in the 1920s.

Although they had been set aside (1915) to provide the navy with emergency fuel reserves, the oil fields—by order of Harding—were placed (1921) under jurisdiction of the Department of the Interior. In 1922, Secretary of the Interior Albert B. Fall arranged for the lease of the fields to private developers, without competitive bidding, in exchange for the construction of naval oil-storage depots. A public scandal resulted in 1924 when a congressional investigative committee heard testimony of suspicious dealings involving politicians. The private developers had made large profits as a result of the arrangements with Fall, who was convicted of receiving a bribe, fired, and sentenced to one year in prison. In 1927 the oil reserves reverted to U.S. government control through a Supreme Court decision.

tear gas Chemical substances that produce severe irritation of the lachrymal (tear) glands are known as lachrymatory agents or tear gases. The term *gas* is misleading, because many irritant chemicals are disseminated in solid (tiny particles) or liquid form. One of the most common tear gases used today, chloroacetophenone (code-named CN), was developed during World War I for one of the first large-scale chemical-warfare actions. The irritant produces tearing very quickly. If the concentration is high enough or if the time of exposure is prolonged, irritation of the mucous membranes of the nose and throat may also occur. High exposures in a confined space may produce some edema or fluid accumulation in the lungs, and in a few cases the chemical may have been the cause of death. A more recent "tearing" or irritant agent, which received extensive use by U.S. forces in Vietnam, is the chemical agent known as CS (2-chlorobenzylidenemalononitrile). In very mild exposures, CS almost instantly produces copious tearing and an irritation of the nose, mouth, and throat. At higher concentrations, the effects are almost unbearable. Recovery from CS exposure takes longer than that from CN.

MACE, a form of tear gas used primarily to subdue individuals in close-encounter situations, is sprayed from a hand-held can.

tears Tears, which are secreted by the two lachrimal glands, bathe and cleanse the cornea of the EYE. They are salty and contain lysozyme, an enzyme that kills bacteria and therefore minimizes eye infections. Tears flow over the conjunctiva, the moist membrane that covers each eyeball, and are collected by lachrimal canals located at the inner angle of each eye. From the canals, tears pass by way of the nasal lachrimal ducts into the nasal cavities.

Teasdale, Sara [teez'-dayl] Sara Teasdale, b. St. Louis, Mo., Aug. 8, 1884, d. Jan. 29, 1933, was one of the finest American lyric poets of her generation. Marked by simplicity, clarity, and a recurring sense of loss, her love lyrics, as in *Love Songs* (1917), show the influence of Christina Rossetti. She published several additional volumes, including *Flame and Shadow* (1920), and edited a poetry anthology for young people, *Rainbow Gold* (1922). The poetry of her later collections, *Dark of the Moon* (1926) and *Strange Victory* (1933), is increasingly subtle and haunted by suffering. She died a suicide.

teasel [tee'-zul] *Teasels* are any of about 15 species of biennial or perennial plants of the genus *Dipsacus* in the family Dipsacaceae. They are native to the temperate

The common teasel is an herb native to southern Eurasia and northern Africa. Its burrlike heads have often been used by weavers to comb the nap of wool textiles; its seeds are used for bird feed.

regions of Europe, western Asia, and North Africa. The plants are spiny, with opposite leaves, and bear cone-shaped heads of small purple flowers encased in prickly bracts. A few species of teasel are cultivated as ornamentals. Root infusions of teasel plants have been used medicinally as ointments and for stomach relief.

The most commercially important teasel is the biennial species Fuller's teasel, *D. sativus*, whose flower head has curved bracts that have long been used to raise (to "tease") the napped surfaces on wool and other fabrics. The term *teasel* may also refer to any implement used for raising the nap on fabrics. The value of the teasel flower head as a comb is that its curved bracts will yield to any real obstruction and not tear the fabric as metallic combs might.

Tebaldi, Renata [tay-bahl'-dee] Noted for her sumptuous voice as well as her affecting portrayals of such operatic heroines as Desdemona in Verdi's *Otello*, Renata Tebaldi, b. Feb. 1, 1922, was one of the most popular and lauded Italian sopranos of the 1950s and '60s. She studied with Carmen Melis and made her debut as Elena in Boito's *Mefistofele* in 1944. Encouraged by Arturo Toscanini, she became a principal singer at La Scala, Covent Garden, and, finally, the Metropolitan Opera, where she first appeared as Desdemona in 1955.

technetium [tek-nee'-shee-uhm] The chemical element technetium is a radioactive metal of Group VIIB of the PERIODIC TABLE. Its symbol is Tc, its atomic number is 43, and its atomic weight is 99 (stablest isotope). In 1937, C. Perrier and Emilio Segrè bombarded molybdenum with deuterons and produced the isotope ^{97}Tc. They named the new element technetium, from the Greek for "artificial," because technetium was the first element produced artificially. The chemical behavior of technetium resembles that of rhenium. In medicine, technetium is used in brain, thyroid, and other organ scanning.

technical education Technical education prepares individuals for entry into occupations that lie between the skilled crafts and the engineering and scientific professions. These occupations usually involve the use of scientific apparatus and machinery, often in laboratories. Programs in technical education stress the understanding and application of the basic principles of science and mathematics. Because of this emphasis, technical education differs from vocational-education programs, which aim to develop manual and technical skills generally related to a single occupation.

The Industrial Revolution in the United States in the 19th century was the single most important factor in signaling the need for technical education. Because apprentice-training programs could no longer meet the demand for a pool of technically trained talent, a number of mechanics schools or institutes were founded. Important among these were the General Society of Mechanics and Tradesmen in New York City (1820), the Rensselaer School (later Rensselaer Polytechnic Institute) in Troy, N.Y. (1824), and the Ohio Mechanics Institute in Cincinnati, Ohio (1828). Federal support for such programs came later with the passage of the Morrill Acts in 1862, which promoted public agricultural and mechanical colleges. The Smith-Hughes Act of 1917 funded public vocational-technical programs at the secondary-school level and adult-education programs in public schools.

A technologist, who usually has a 4-year baccalaureate degree from a technical institute or college, is a person qualified for a technical-supervisory or management position. Some jobs for technologists require only from 2 to 4 years of study. The technologist must have an appropriate background in science and mathematics, shop or laboratory courses, management and administration, general education, and frequently a specialized internship.

A technician is a person qualified for positions requiring applied technical skill and knowledge. Such work is narrower in scope than that of a technologist, and the qualifications generally include completion of a 2-year associate-degree program from a community college or technical institute and often on-the-job training. This training stresses applications of science and mathematics to laboratory operations and processes.

A technical assistant is a person qualified to operate complex machines, instruments, and equipment. The tasks of such people as a dental assistant who cleans teeth and uses X-ray equipment are highly specialized. Such people become qualified through on-the-job training or in a community college or technical school through 3- to 12-month programs that combine class work with field experience.

technology Technology is a major cultural determinant, no less important in shaping human lives than philosophy, religion, social organization, or political systems. In the broadest sense, these forces are also aspects of technology. The French sociologist Jacques Ellul has defined *la technique* as the totality of all rational methods in every field of human activity, so that, for example, education, law, sports, propaganda, and the social sciences are all technologies in that sense. At the other end of the scale, common parlance limits the term's meaning to specific industrial arts.

The terms *science* and *technology* are often confounded. The confusion arises because so much of contemporary technology is based on the natural sciences—such disciplines as physics, chemistry, biology, and other branches of knowledge that deal with the study, measurement, and understanding of natural phenomena. The achievements of the electronics, pharmaceutical, and plastics industries are based on a huge body of scientific investigation.

In simplest terms, the concern of science is "why," and of technology, "how." The relationship between the two is actually much more complex, however, and it varies from industry to industry: some technologies are science intensive, whereas the manufacture of such items as cigarettes or furniture depends much less on science. In fact, much of modern technology developed without any scientific input whatever, and there are many examples of entire sciences arising from earlier technologies or developing in an effort to explain findings made by scientifically naive artisans. For instance, gunnery led to ballistics; the steam engine, to thermodynamics; powered flight, to aerodynamics; primitive metalworking, to metallurgy; and communications, to radio astronomy.

Technological Innovation

Industrial Revolutions. During certain periods in history innovations in technology have grown at such a rapid pace that they have produced what have become known as industrial revolutions. The term INDUSTRIAL REVOLUTION originally referred to the developments that transformed Great Britain, between 1750 and 1830, from a largely rural population making a living almost entirely from agriculture to a town-centered society engaged increasingly in factory manufacture. Other European nations underwent the same process soon thereafter, followed by others during the 19th century, and still others (such as Russia and Japan) in the first half of the 20th century. In some countries this transformation is only now taking place or still lies in the future.

Research and Development. In the 20th century technological innovation has been to a large degree institutionalized by organized research and development (R & D). This phenomenon paralleled, and to some extent antedated, the Second Industrial Revolution. Some large firms in science-intensive industries maintain R & D laboratories employing thousands of people. R & D organizations operated or largely sponsored by national governments are another source of technological innovation, as are the engineering and science departments and research institutes of universities.

Under these circumstances private inventors are likely to play a progressively smaller role in bringing about innovation, although they are not likely to disappear altogether. That smaller role is especially evident in the stages of innovation that follow INVENTION—development, testing, design, production, marketing, and distribution—that now often require financial and managerial resources that are beyond the capabilities of the inventor-entrepreneur.

Technology and Society

Examples abound of the ways technology cuts across vastly different political and economic systems. The sociologist Reinhard Bendix compared the American, British, and Soviet experience in his *Work and Authority in Industry* (1956) and found that the managerial concerns about the attitudes of workers and productivity were similar in all three countries. Even earlier, James Burnham in *The Managerial Revolution* (1941) put the case for a convergence toward similar patterns of industrial organization in democratic, fascist, and communist societies. More recently, such critics as Jacques Ellul have concluded even more sweepingly that technology has its own dynamic that not only reaches across political ideologies but also represents a monstrous force that must be contained with the utmost vigilance if it is not to enslave people. This negative view finds expression in various ways, from calls for a complete halt in further technological development to suggestions of milder forms of controlling or taming technology.

Technology Assessment. Some observers insist that the real dangers from technology, such as irreversible ecological damage and widely fluctuating employment patterns, can be dealt with if the dangers are known in advance. The U.S. Office of Technology Assessment (OTA) was established in 1973 to advise Congress on the potential social and environmental effects of new technologies; on their likely costs; and on their impacts on already-existing technological systems.

Technology Transfer. Because the rate of technological development is uneven across the globe, technology is sometimes charged with contributing to the gap between rich and poor nations and thus increasing international tensions. The opposite view holds that only through technology can the less-developed countries improve their lot, provided the more advanced nations use technology to help the less-developed countries rather than to hold them in thrall. Supplying the products of technology is one way of providing help, especially if these products are appropriate to the recipients' needs. Giant tractors are of little use in a region in which intensive agriculture at a bare subsistence level prevails. Hand tools, small motors, and other implements of intermediate technology are more welcome in such an environment.

Even more effective is transfer of the technology itself, by the provision of blueprints, models, designs, patents, and other know-how and by the establishment of workshops, factories, training programs, and agricultural and engineering colleges. Less obvious but equally important is the need for basic science curricula, professional organizations, and publications. These and other intellectual underpinnings of technology are taken for granted in developed countries but are in short supply in most less-developed countries. Technology transfer is supported by the governments of most developed nations, some of which may hope to gain not only a relaxation of tensions but an enlargement of their own economic, political, and cultural spheres of influence. Technology transfer is also the province of several technical and specialized agencies of the United Nations and other international organizations.

In recent years the term *technology transfer* has taken on a variety of new meanings. Business firms often look for possible partners in other countries, offering U.S. technological expertise in the hope of penetrating overseas markets. At the same time, workers on the crest of new technologies, such as the SOLAR CELL, remember the fate of semiconductors, high-fidelity stereos, and VCRs—all technologies that were pioneered in the United States but developed and exploited by foreign companies. The U.S. government has been extremely wary of allowing the export of high technology to unfriendly nations, especially in the computer field.

technology, history of The history of technology is the study of the changes through which economic, cultural, and military techniques have evolved and of the social, economic, and political consequences those changes have produced. To reach a full understanding of the history of technology, historians cannot confine their attention to instruments and techniques alone but must consider as well a large domain of events, some of them seemingly remote, that have had a bearing on the evolution of technology: the role of the technologist and engineer and their status and training; geography and climate; division of labor; the processes of invention and innovation; the diffusion of knowledge; the technical consequences of research; the relationship between technology and science; traditions of art; and the development of crafts.

The history of technology begins with the use of stone tools by the earliest humans—and perhaps even by their prehuman ancestors. The field of study may be divided into four major periods: the Paleolithic (Old Stone Age), beginning about 2.5 million years ago; the Neolithic (New Stone Age) transition, dating from about 9000 BC; agricultural civilization, which originated with the invention of the plow in the 4th millennium BC; and industrial civilization, which covers the past 250 years. These divisions are approximate, schematic, and sometimes extensively overlapping; even today, with agricultural and industrial civilizations existing side by side and each incorporating technology that is characteristic of the other, there also exist isolated groups of people who still employ Stone Age technology. Similarly, rudimentary forms of agriculture (or at least horticulture) may have been practiced occasionally during the Paleolithic, which was characterized by hunting and gathering.

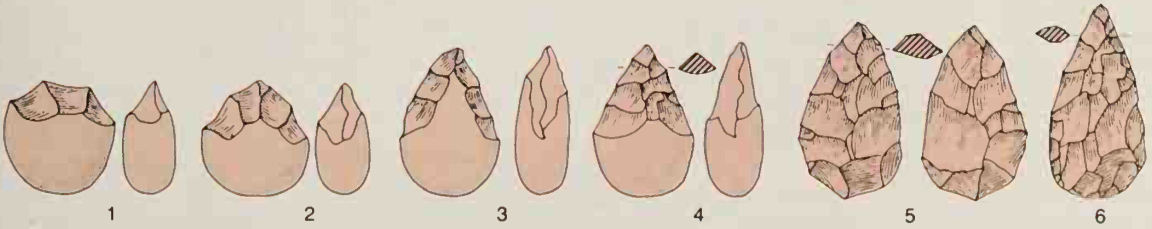
The Paleolithic era and the Neolithic transition, which jointly constitute more than 99% of the time span of technological history, lie properly in the domain of the prehistorian—mainly the archaeologist, anthropologist, and paleontologist. This article briefly summarizes Paleolithic and Neolithic technology, treats agricultural civilization in some detail, and highlights the beginnings of industrial civiliation in the 18th century. The course of the Industrial Revolution is discussed in more detail in that entry, and 19th- and 20th-century technology is detailed in many entries on the individual industries and technologies in such fields as power, transportation, construction, communication, materials technology, electronics, and medicine.

Paleolithic and Neolithic Prelude

Paleolithic technology (see Paleolithic Period) was the creation of both modern humans (*Homo sapiens*) and at least one extinct species, *Homo erectus*. Hunting of animals and gathering of eggs, insects, and edible plants were the dominant economic activities. On the evidence of surviving hunting-gathering societies, it may be supposed that a dual economy existed in which men hunted and women gathered. By the end of the Paleolithic, humanity's technological repertoire included stone tools, the use of fire, spears and spear throwers, the bow and arrow, simple oil lamps, pigments, mortars and pestles, and bone sewing needles.

The Neolithic transition (see Neolithic Period) is characterized by the origins of food production through the development of animal and plant husbandry. There is indirect evidence that the sheep was domesticated in the Middle East about 9000 BC. Over the next three millennia wild cereal plants were domesticated, animal and plant husbandry were further developed, and small farming communities were formed (often in upland areas, where rainfall was adequate). Cultivation was accomplished with

(Left) *The primitive wooded scratch plow seen in this Egyptian tomb painting (c. 1600 BC) was developed from the digging stick.* (Below) *The chopping tool* (1) *was developed about 2.5 million years ago. It was fashioned from a rounded stone by chipping one end with another stone to create a jagged cutting edge. During the next 2 million years, sharper tools with thinner edges were developed* (2), *longer stones were used* (3, 4), *and chipping was extended over the entire surface* (5)*—resulting in the hand ax* (6), *a thinner, sharper, almond-shaped tool.*



the use of the digging stick and the wood hoe. The Paleolithic division of labor persisted into the Neolithic Period, with men tending herds of animals and women managing garden plots. Late Neolithic stone tools were improved by polishing, and polished stone axes were used to prepare forest clearings for cultivation. Modern tests with Neolithic axes have demonstrated their remarkable effectiveness in the felling of trees.

Neolithic crafts included pottery, spinning and weaving, basketmaking, and house building. The discovery of Neolithic artifacts on islands in the Mediterranean also testified to the early use of boats.

Agricultural Civilization

The invention that marked the beginning of agricultural civilization was the ox-drawn plow. It originated in the Middle East in the 4th millennium BC. Although the circumstances of its invention are unknown, the early scratch plow (or ard) was probably derived through modifications of the Neolithic adze and the hoe. Because traction was supplied by oxen, the provinces of animal husbandry and plant cultivation were merged, and the dual economy that had originated in the Paleolithic was now replaced by an economy of field cultivation. Combined with the techniques of fallowing, irrigation, and flood control that date from the same period, plow agriculture was successfully established in the rain-sparse river valleys of Mesopotamia, Egypt, and India, and the breakthrough to civilization was accomplished.

Plow agriculture was accompanied by an array of momentous developments. Writing evolved; the political state came into being (possibly through the conflicting pressures of expanding population and limited fertile land in the river valleys); chronic warfare set in; and copper and bronze metallurgy was devised.

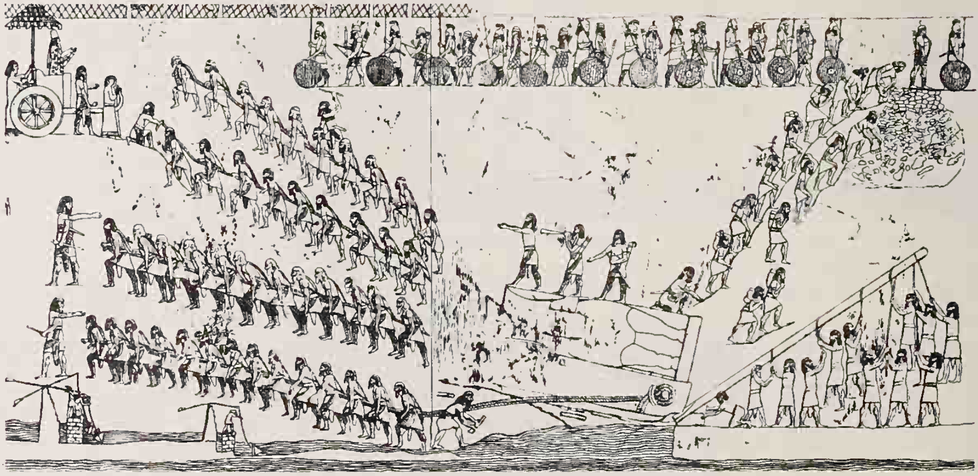
Bronze Age. The earliest phase of agricultural civilization is commonly known as the BRONZE AGE. The use of copper and bronze (an alloy of copper and tin) gave rise to a variety of techniques and devices and to a complex of skilled artisans. Copper ores had to be mined and tin ores collected, often from distant sources, thereby encouraging commerce, cultural intercourse, and sometimes conquest; furnaces, crucibles, and fuels had to be provided for the smelting of the ores; and intricate molds, often made of several pieces, had to be prepared for the casting of the metal.

Copper and bronze hand weapons came into use, but by far the most important innovation in military technology during the Bronze Age was the horse-drawn two-wheeled chariot. Although cumbersome two- and four-wheeled carts had been invented earlier, the highly mobile war chariot carrying an archer armed with the short, compound bow revolutionized military tactics after 1700 BC.

Building technology also developed rapidly during the Bronze Age and, in the form of pyramidal structures, reached monumental proportions. In Mesopotamia molded, kiln-dried bricks were the favored building material for large structures, whereas in Egypt the famous pyramids were commonly built of limestone blocks. After this limestone was quarried with wooden, stone, and copper tools, the blocks were transported to the building site by barges and sledges. Methods of construction and the achievement of structural stability, however (rather than the quarrying and transportation of materials), presented the most formidable problems that Bronze Age builders succeeded in solving.

The substantial technical and cultural progress of these early civilizations, the emergence of crafts whose practitioners were relieved of the need to participate in food production, the increase in population, and the rise of many urban societies centered in impressively wealthy cities were entirely based on the productivity, and hence on the food surpluses, of plow agriculture. At first, surpluses adequate to sustain civilization were possible only on irrigated land, so that the earliest civilizations were confined to alluvial river valleys. As the technology of plow agriculture improved, civilization spread to rain-fed lands away from the river valleys.

Iron Age. By the end of the 2d millennium BC iron metallurgy was developed, and a new technical era began.



For thousands of years human muscles were the only source of power for building construction. King Sennacherib of Assyria used slave laborers to build (c.700 BC) his palace at Nineveh. More than 40 laborers were needed to pull this sledge with its 2-ton stone block (center), *while another gang used a long lever at the rear of the sledge to reduce friction.*

About 1000 BC an IRON AGE civilization arose in Greece that was based on rain-watered agriculture and used the implements of the new metallurgy. The production of wrought iron called for a technology fundamentally different from that of either copper or bronze. Higher furnace temperatures were required, and the iron emerged from the furnace as a red-hot, pasty ball that had to be worked by hammering, rather than as liquid metal that could be poured from crucibles into molds.

Bronze and iron found their widest use in the paraphernalia of war. Hoplites (from the Greek *hoplon,* a round shield)—ranks of drilled infantry armored with helmets, corselets, greaves, and shields and armed with iron-tipped spears—became the backbone of Greek military power. The geographical position of Greece in the Mediterranean encouraged the development of ocean-borne commerce, and the Greeks built and maintained a large fleet of merchant ships and men-of-war.

Greek building technology provided the technical basis for a notable architecture (see GREEK ARCHITECTURE). Although the arch had been invented long before, Greek builders, using stone as their material, confined themselves to the post-and-lintel (column-and-beam) structural mode. To enable stone beams to resist cracking at their lower surfaces (where they are stretched), they were necessarily of massive size, with short spans, and rested on many columns. On occasion the Greek builders embedded wrought-iron bars in grooves formed in the beams to keep the tension in the stone within an acceptable range.

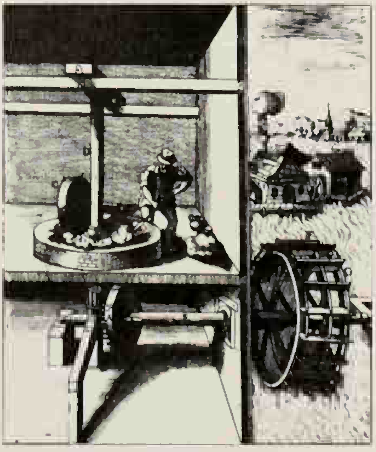
The Greeks coined the term *architekton* to describe the practitioners of the fields encompassed in modern times by the disciplines of engineering and architecture—building, tunneling, mining, and hydraulic projects. Later, during the period of Greek imperialism (336–323 BC) under Alexander the Great, the *architekton* was engaged in the design and construction of the catapult, with which Alexander supplied his armies.

In general, Greek technology remained independent of the scientific tradition that Greek natural philosophers were creating. Between 250 BC and AD 100, however, a school of scientist-engineers flourished at Alexandria and produced treatises on mechanical and pneumatic devices that display an interest both in the philosophy of nature and in the application of empirical formulas to engineering design.

Roman and Medieval Innovations. The skill of Roman engineers is legendary. In the art of building they mastered the technique of the stone arch and its variations in the vault and the dome (see ARCH AND VAULT; ROMAN ART AND ARCHITECTURE). In contrast to the post-and-lintel method, buildings employing arches primarily produce compressive forces and thereby improve the efficiency of stone, which is desperately weak under tension. Characteristically, the stone arch is composed of wedge-shaped blocks that must be supported during the construction process, generally by a temporary wooden scaffold, until the arch is complete. Once the arch is complete, the wedges are in equilibrium, provided that the horizontal thrust is resisted either externally by buttresses or internally by a tie-bar across the opening. The same principle was adapted to the construction of vaults and domes. The accomplishments of Roman engineers are best illustrated by their refinement of AQUEDUCT design, in which they combine elements of bridge building, road making, tunneling, pressure piping, and reservoir construction.

The Pont du Gard, a Roman aqueduct near Remoulins, France, is an impressive example of Roman engineering genius. Part of a 41-km (25.5-mi) water-supply system, it has three tiers of arches that support a water channel running 49 m (160 ft) above the Gard River valley.

The flowering of agricultural civilization in Europe north of Rome during the Middle Ages was foreshadowed by Roman technical innovations. Roman engineers were familiar with the principle of the WATERWHEEL and its associated gearing as early as the 1st century BC, and they occasionally employed it in the construction of MILLS. Even more important was the development of a heavy PLOW capable of turning the clay soils of northern Europe. The ancient light plow drawn by a pair of oxen was effective in the dry climates of the Middle East and the Mediterranean world, where the soils were light and friable. In northern Italy and in transalpine Europe the light plow permitted tillage only on well-drained upland soils, where-


The vertical water mill, which uses a waterwheel that rotates in a vertical plane to harness the energy of flowing water, was designed by Roman engineers as early as the 1st century BC. Here the stream turns the waterwheel, which drives gears that convert the energy into a rotary motion used to grind corn.

The development of heavy plows with moldboards made it possible to cultivate the clay soils of northern Europe. The moldboard—a curved plate that lifts and turns the soil—helped to improve drainage, aerate the soil, and uproot weeds.

as the wet, cohesive soils of the vast lowlands and the north European plain could not be cultivated. The heavy plow with its vertical coulter, horizontal plowshare, and moldboard to turn the soil, mounted on wheels and drawn by teams of four, six, or eight animals yoked in pairs, made possible the civilization of northern Europe.

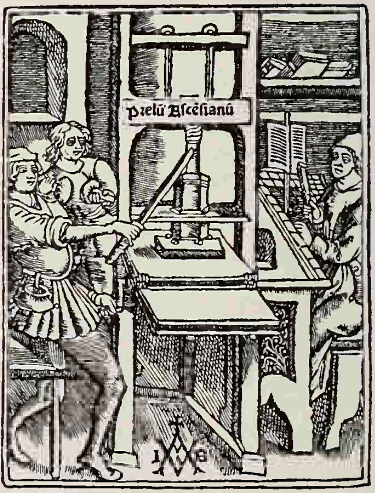
As the heavy plow began to transform European agriculture in the 9th and 10th centuries, property relations and social patterns also began to change. The square tracts characteristic of light-plow cultivation (because the fields were cross-plowed) gave way to elongated tracts (the "long acre"), on which the heavy plow would not have to be turned around as often. Peasants found it necessary to pool their resources in order to form the teams of oxen required to pull a heavy plow. The heavy plow and communal tillage became the basis of the manorial system, which provided medieval Europe with food surpluses, an increasing number of skilled artisans removed from the web of food production, and a growing population. About the same time, the introduction of the HORSESHOE and the horse collar permitted the substitution of the horse, with its greater speed and endurance, for the ox, completing the agricultural revolution that the heavy plow had initiated.

The Middle Ages in Europe were in general prodigiously innovative. In the 8th century iron became widely available and once again was adapted to military needs. Heavy cavalry, its lance-bearing riders armored with wrought iron and stabilized by SADDLE and stirrups, became the shock troops of medieval Europe. In the 12th century water mills, which had not been widely used until then, and windmills, the concept of which was only then reaching Europe from the East, brought a revolution in the production of power (see WINDMILLS AND WIND POWER). At first both devices were used mainly in corn mills, but the windmill soon acquired its characteristic role as a water-pumping engine, and the waterwheel was adapted to a variety of enterprises including sawmills, hammer mills, and stamping mills. The application of waterpower to the bellows of the blast furnace made possible for the first time the production of large quantities of cast iron.

The technical and cultural progress of the late Middle Ages is most vividly exemplified by Gothic architecture (see GOTHIC ART AND ARCHITECTURE). The urbanization of Europe was accompanied by waves of CATHEDRAL building, and in the 12th century builders introduced a series of innovations that enabled them to achieve structural lightness while carrying their vaults to extreme heights and admitting substantially more light through large expanses of glass windows. The flying BUTTRESS, calculated to resist the thrust of the central vaults, became a hallmark of these lofty structures, which, within a century, achieved vault heights of 49 m (160 ft). The master masons who designed these remarkable buildings proceeded without the insights of science, basing their specifications only on experience, rules of thumb, intuition, and daring.

Medieval Europe's inventive impulse contained the seeds of both the reformation of medieval society and the achievement of European influence throughout the world. During the 14th century FIREARMS appeared in Europe. Early guns were made either of wrought-iron strips hooped together to form the barrel or of cast brass or bronze. Ironically, the bell-founders, who had refined their technique in the casting of church BELLS, now turned to the casting of CANNONS. The craft of the gunsmith came into being, and national arsenals were established. Before the middle of the 16th century, English founders had perfected the casting of iron, instead of bronze, guns, thereby sharply reducing the cost of ordnance.

The medieval castle was an easy target for the new weapons, and, along with large catapults, the castle passed from the scene. New FORTIFICATIONS were now required—polygonal and star-shaped—to increase the length of ramparts on which guns could be mounted and to present unfavorable shot-deflection angles to attacking gunners. Hand guns were also rapidly developed, and by



This 1507 woodcut depicts two workers manipulating a printing press while a third (right) *sets words into type. The Gutenberg press, developed during the 15th century, made possible the widespread, rapid diffusion of culture and knowledge.*

the end of the 16th century they had swept the longbow from the field. The MUSKET in particular made infantry once again the most decisive force on the battlefield.

Parallel with these developments in land warfare, the sailing SHIP was being transformed into a formidable instrument of naval power, world exploration, and commerce. In the 15th century the carrack appeared—full-rigged, more manageable than earlier sailing ships, and capable of ocean voyaging. Armed with hundreds of iron and brass guns, carracks of more than 1,000 tons served as both merchantmen and men-of-war. In the second half of the 16th century the galleon was developed primarily as a fighting ship. The GALLEON showed most of its guns through ports cut in the hull, and its handling was improved over that of earlier ships by increasing the length-to-breadth ratio of the hull and by reducing the size of the forecastle and the afterdeck.

The Renaissance. From the 15th through the 17th century, the period designated by cultural historians as the Renaissance, the new warfare employing guns and armed ships changed Europe from a provincial region to a center of world power. The New World was explored and conquered, and commerce with the East—carried on by armed merchantmen—grew increasingly profitable. European cultural life flourished, abetted by the appearance of the printed book (see PRINTING) during the 15th century. Additionally, in turn, the widening interest in technology and industry was reflected in the publication of richly illustrated technical treatises.

The new technology produced new problems, partly as a result of the increased use of iron in the making of cast-iron ordnance. Because the blast furnace was charged with ore and fuel in intimate contact, attempts to use coal as the fuel invariably failed because the impurities that it contained were absorbed by the iron. It was thus necessary to charge the blast furnace with charcoal (derived from wood) as the fuel, and by the end of the 16th century the iron industry was consuming timber at a prodigious rate. Combined with the demands of SHIPBUILDING (the largest ships of the time each required several thousand trees in their construction), the iron industry was rapidly deforesting Europe. The "timber famine" was most severely evident in the British Isles, where the making of both guns and ships was booming.

Shortly afterward a second problem arose, this one in the mining industry. As mines were sunk to ever greater depths in search of minerals, the shafts filled with groundwater and had to be constantly pumped. A variety of devices were employed, including the suction pump, which was powered by the draft of animals at the pithead. By the end of the 17th century, however, it became evident that more-powerful engines would be needed.

Industrial Civilization: Eighteenth Century

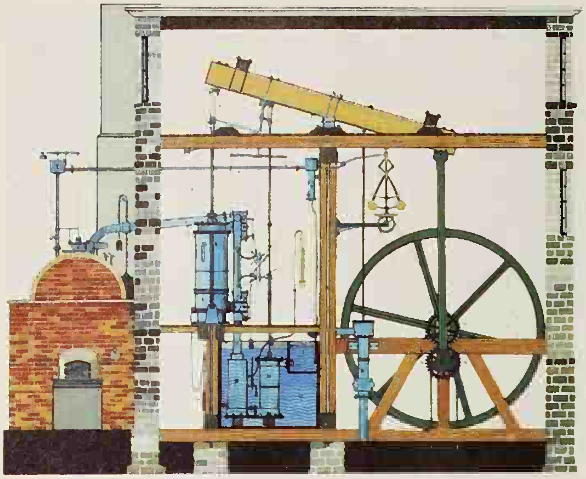
Both the problem of high consumption of timber in the smelting of iron ore and the problem of flooding in deep mines received technical solutions early in the 18th century. These solutions, both of which were reached in Great Britain, where the problems were most sharply felt, set the stage for the Industrial Revolution.

Abraham Darby's Coalbrookdale ironworks in Shropshire, England, used another major technological development leading to the Industrial Revolution: in 1709, Darby learned how to smelt iron with coke instead of wood-derived charcoal.

In 1709 the ironmaster Abraham Darby I succeeded in producing sound cast iron in a blast furnace charged with iron ore and coal (and soon afterward with coke, derived from coal). In 1712 another Englishman engaged in the iron trade, Thomas NEWCOMEN, invented the STEAM ENGINE for the purpose of driving the pumps used in clearing groundwater from mine shafts. By the end of the 18th century the British iron industry had largely replaced charcoal with coke. Within a short time, too, Newcomen engines were serving most of the larger collieries in Great Britain, making possible the opening of new mines that otherwise would have been unworkable.

These two innovations, the steam engine and the making of iron with coal, not only broke critical bottlenecks that were constraining economic progress, but also produced an interlocked complex of industrial development: the steam engine promoted coal production by clearing flooded mine shafts; coal (in the form of coke) revived the iron industry, which had begun to slump as a result of the timber famine; iron was used in the further production of steam engines, and this in turn demanded improved metalworking techniques.

In the 1760s, James WATT increased the efficiency of the Newcomen engine by providing it with a separate condenser, thereby obviating the need alternately to heat and cool the cylinder and piston. Watt followed this important invention with a remarkable series of additional contributions: "sun-and-planet" gearing to translate the reciprocating motion of the steam engine into rotary motion for operating mills; the double-acting steam engine and the "parallel motion" used to connect its rigid piston rods to the overhead beam without causing the rods to wobble; the principle of steam cutoff, whereby Watt recognized that because of its expansive power steam need not be admitted into the cylinder during the entire stroke; and an indicator for determining the pressure in the cylinder during the cycle. John Wilkinson designed a boring machine



James Watt's reciprocating steam engine, developed during the late 18th century, was a major stimulus to the Industrial Revolution. The motion of the steam-driven rocking beam (top) *was converted into the rotary motion of the flywheel* (right) *for driving factory engines.*

that radically improved the accuracy with which steam-engine cylinders could be bored; the steam engine was combined with cast-iron blowing cylinders to produce a more powerful draft in the blast furnace than the older bellows could provide; and by the beginning of the 19th century the compact, high-pressure steam engine (in contrast with the Newcomen and Watt engines, which relied on atmospheric pressure) was invented, opening the way to the construction of steamboats and steam locomotives.

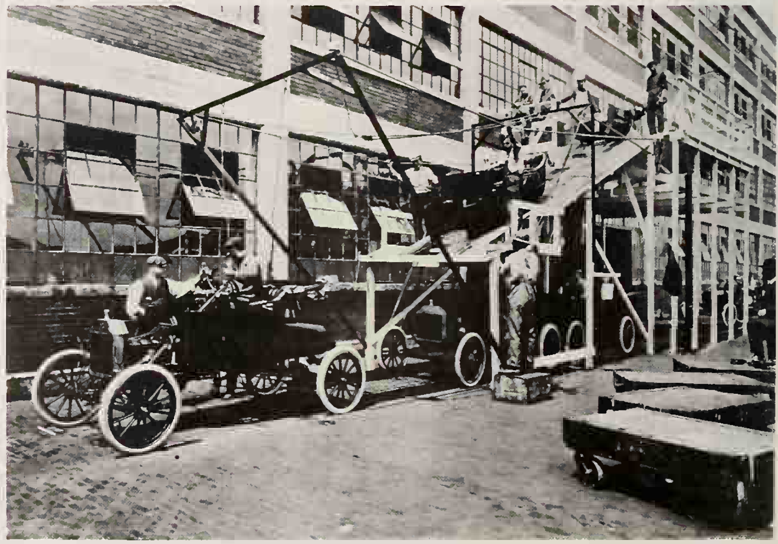
This web of technical innovation is characteristic of the Industrial Revolution. It may be seen as well in the TEXTILE INDUSTRIES, where SPINNING and WEAVING machinery were alternately improved in a pattern of reciprocating challenge and response. The application of steam power further stimulated the concentration of industry in mills and factories and, where it replaced the waterwheel, steam power released industry from its need to be near rural waterpower sites. Cities became the hubs of industrial growth and the centers to which waves of agrarian population migrated as industrial civilization took hold.

Agriculture, too, was changing (see AGRICULTURE, HISTORY OF), and some of the changes furthered the exodus of farmers from the land. The tradition of communal pastures increasingly gave way to enclosed fields, which promoted agriculture by permitting continuous cropping and by improving stock-raising: more fodder could be produced, and the promiscuous breeding of livestock could be prevented. Moreover, during the century following 1750, industry directly affected agriculture by manufacturing new implements and new machines. Many wooden and wrought-iron tools fashioned by local artisans were replaced by cast-iron tools produced in factories. Mechanical devices, some even steam powered, were introduced for reaping, threshing, and plowing.

Iron also changed the landscape as the introduction of structural iron altered the mode of building. Stone had been a hallmark of monumental building throughout the time of agricultural civilization. Public buildings were generally made of stone, and stone-arch bridges dotted the landscape. In the last quarter of the 18th century, however, British ironmasters found a new use for cast iron (which, like stone, is strong in compression and weak in tension) when they succeeded in casting the components of the arch bridge. Early in the 19th century the introduction of structural WROUGHT IRON made possible the large suspension bridge, and by 1850 the wrought-iron tubular bridge for carrying railroads made its appearance.

If the engineer was instrumental in making the Indus-

(Right) *Henry Ford's assembly-line process—shown at the Ford Motor Co. plant at Highland Park, Mich.—further transformed society by putting the public on wheels and was adopted for the mass production of many other goods.* (Below) *Thomas Edison's commercial power station for incandescent lighting opened in New York City on Sept. 4, 1882, shortly after he directed the opening of the world's first such station in London.*



The rapid development of computers in the mid-20th century has revolutionized technology to a degree unsurpassed by previous advances. In this production line for automobiles, robots programmed by computers have replaced human labor.

trial Revolution, it can equally be said that the Industrial Revolution gave rise to the ENGINEERING profession as it is recognized today. Where previously engineers had risen through the ranks of craftsmen, in the 18th century it was becoming apparent that the act of design could be codified in the form of technical training, and the military services began to seek such training for their officer corps. Technical studies penetrated the established universities slowly, and it was in new institutions—such as the École Polytechnique in Paris and the University of London—that engineering first took root in university education.

Modern Industrial Civilization

During the course of the 19th and 20th centuries, people's everyday lives have been changed to extraordinary degrees and in previously unimagined ways by technological advances, which seem increasingly interrelated despite the particular field. Achievements in transportation, communications, and the conversion of energy have effected a modern society characterized by great speed. Medical knowledge has provided longer and healthier human life spans. Electronics, especially computer technology, is not only in itself a huge field, but makes possible further advances in all other areas of technology. The use and improvement of tens of thousands of materials in all forms of industry have made for better standards of living and much more leisure time.

Most would agree, however, that such stupendous technological achievements do not come without a price. Sophisticated weapons technology has provided the means for mass destruction of life and property; instantaneous communication and wide dissemination of information of all kinds have brought with them less privacy; the great use and abuse of natural resources has wrought severe threats to the environment; and the comparatively frenetic pace of human existance may ultimately call into question many of the benefits of high technology.

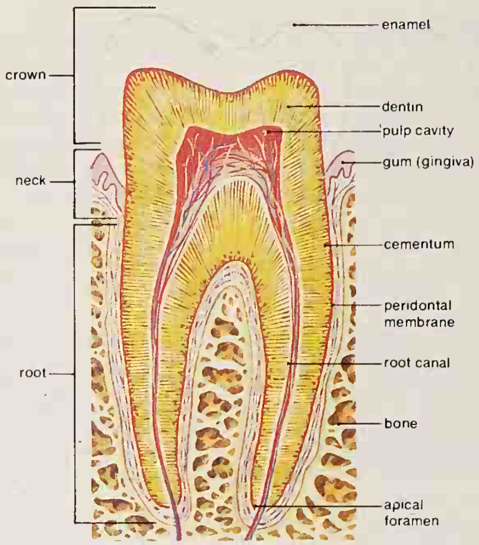
Tecumseh [tuh-kuhm'-suh] Tecumseh, b. 1768, d. Oct. 5, 1813, was a SHAWNEE warrior chief who with his twin brother, the SHAWNEE PROPHET, attempted to stop the advance of white settlement in the Old Northwest. Tecumseh believed that Indians must return to a state of purity; that they must forget intertribal rivalries and confederate; and that individual tribes must not sell land that all Indians held in common. In 1809 tribes in the Indiana Territory ceded much of their land to the United States. Tecumseh protested to Gov. William Henry HARRISON, but in vain. In the fall of 1811 he determined to carry his message to the CHICKASAW, CHOCTAW, and CREEK. He went south, leaving his brother in charge at Prophet's Town, near Tippecanoe Creek, a utopian village where the Indians were to practice Tecumseh's principles. The Prophet ignored Tecumseh's warning not to attack Harrison's nearby forces. The Battle of Tippecanoe (see TIPPECANOE, BATTLE OF) was not decisive, but Prophet's Town was destroyed and Indian resistance broken. After Tecumseh's return, he joined the British against the Americans in the WAR OF 1812. As a brigadier general, Tecumseh led 2,000 warriors. He was killed at the Battle of the Thames at Chatham, Ontario.

Tecumseh, a Shawnee chief, united midwestern Indian tribes under the common goal of resisting encroachment on Indian lands. After his supporters were routed in 1811 at the Battle of Tippecanoe, Tecumseh joined forces with the British. Two years later he was slain in Upper Canada at the Battle of the Thames. (Field Museum of Natural History, Chicago.)

teenagers see ADOLESCENCE; YOUNG PEOPLE

teeth Teeth are numerous, hard tissue structures in the mouths of animals—vertebrate and invertebrate—used to tear, crush, and grind food. Among other purposes, they are used for defense (biting). The shape of teeth, their structure, their number, and the means of their attachment to the jaws vary considerably. All true teeth typically have three layers.

Human Teeth. In humans the teeth are composed of an inner layer of dentin that, above the gum line, is covered by a layer of enamel. Called the crown, this part of the tooth is extremely hard. The root portion of the tooth is covered with a bonelike substance called cementum. The root is embedded in the jawbone and lies in a socket,



A human tooth consists of three regions: an exposed portion, the crown; a root, which embeds in the jawbone; and a slightly constricted neck at the gum level. The three layers of a tooth are the dentin, which makes up most of the tooth; a hard enamel, which covers the dentin of the crown; and the pulp, composed of connective tissue rich in nerves and blood vessels. These vessels and nerves enter and leave the tooth through the apical foramen. The periodontal membrane lines the tooth socket and secretes the bony cementum that holds the tooth in place.

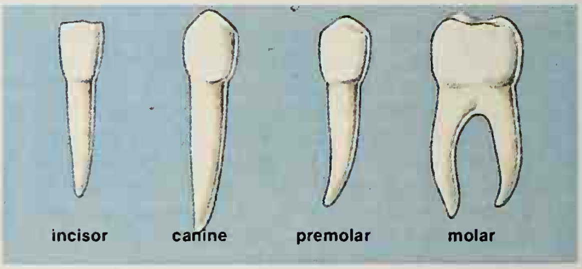
where the cementum is attached to the adjacent bone by a periodontal membrane consisting of fine connective-tissue fibers. The tooth is also attached to the gum tissue (gingiva). The first of the two sets of human teeth—the primary dentition—emerges in steps between the ages of 6 months and 2 years. Between the ages of 6 and 13 years a second, permanent set of teeth sequentially replaces the first. Between the ages of 18 and 21 years, 4 molars called wisdom teeth emerge.

The 20 primary teeth—4 central incisors, 4 lateral incisors, 4 canines (cuspids), and 8 molars—begin to develop prior to birth. They are eventually replaced—beginning around the age of 6—by 32 permanent teeth: 4 central incisors, 4 lateral incisors, 4 cuspids, 8 bicuspids (premolars), and 12 molars. The 4 wisdom teeth develop after the other 8 molars, as the jaws increase in size. If this increase is insufficient, the wisdom teeth may become impacted, that is, wedged between the jawbone and other teeth.

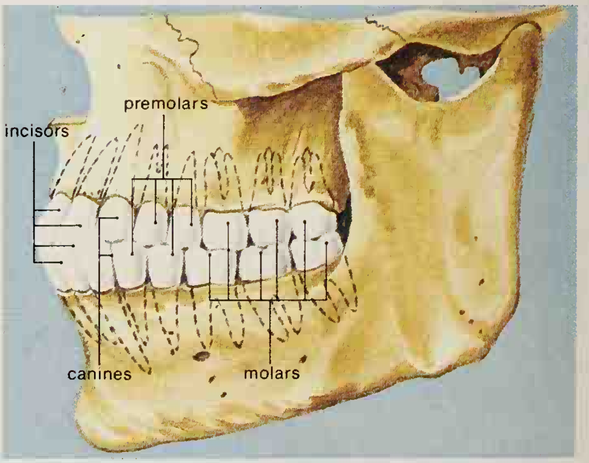
The upper teeth and the lower teeth are shaped in such a manner that they interdigitate (fit together) when the jaws are closed. This fit is essential for the teeth to function properly when biting food with the incisors (front teeth) and when chewing and grinding food with the back teeth (molars and premolars). The molars and premolars have large surfaces with points (called cusps) and grooves so that they fit together extremely well.

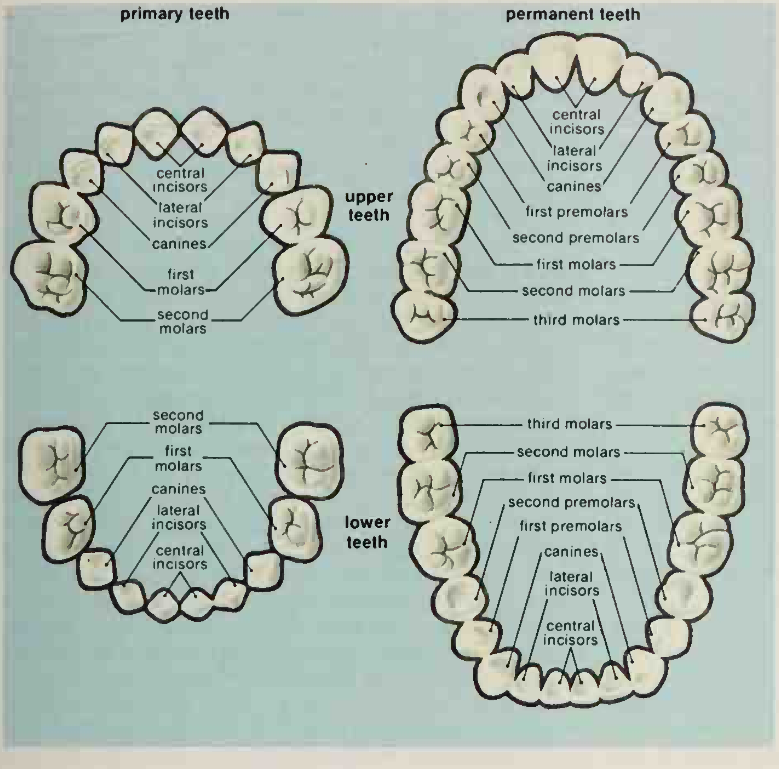
Other Vertebrates. The teeth of mammals differ in dental formula and in shape. The primates have teeth resembling those of humans, but the canine teeth tend to be larger and more pointed, especially in the males. The baboon has two premolars and three molars in each quadrant of the dentition, as do the Old World monkeys. The New World monkeys have three premolars and three molars. Among the carnivores the dog has four premolars and two molars, as well as three incisors and large canines, which are separated from the incisor and posterior teeth. The members of the cat family have two or three premolars and only one molar. Ungulates have premolars and molars with flattened surfaces, necessary for the chewing of grass or hay. Rodents have one incisor and three molars in each quadrant, but the incisors are unusual in that they are constantly developing and erupting as the incisal edges are worn down.

Fish have multiple similar teeth (homodont dentition), which are, essentially, modified scales composed of cornified material and consisting of crowns only. Amphibians tend to have fewer teeth than fish, but reptiles have unusual dental patterns ranging from an absence of teeth in turtles, to one or two rows of sharp teeth ankylosed to bone in snakes, to the thecodont (teeth in sockets) arrangement in



Drawings indicate the four types of permanent human teeth (above) *and their arrangement in the jaws* (below; broken lines represent roots). *Chisel-shaped incisors have sharp edges for cutting. The more pointed canine teeth, or cuspids, are used for tearing food. Premolars, or bicuspids, and molars possess broad crowns with cusps, or elevations, for grinding. Normally, molars each have two or three roots, first upper premolars have two, and the other teeth have one.*





Humans normally develop 20 primary, or deciduous, teeth and 32 permanent teeth. The primary teeth, which begin to form before a child is born, usually push through the gums between the ages of 6 months and 2 years. Central incisors commonly appear when the child is 6 to 8 months old, followed by the lateral incisors at about 7 to 9 months of age, first molars at about 12 to 14 months, canines at from 16 to 20 months, and second molars at roughly 20 to 24 months. The permanent dentition begins to erupt at about 6 or 7 years of age and, by the age of 13 years, has usually replaced all of the primary teeth. The first molars are the first permanent teeth to appear, followed by the central incisors at 6 to 8 years, lateral incisors at 7 to 9 years, canines and premolars at from 9 to 12 years, and second molars at about 11 to 13 years. The third molars, or wisdom teeth, which erupt at approximately 18 to 21 years of age, complete the dentition. The times of eruption may vary widely from one individual to another.

crocodiles. Vertebrates without teeth include all modern birds and some bony fishes in addition to turtles.

Evolution of Teeth. Because of their high degree of calcification, teeth have been well preserved in the fossil record over thousands of years, and they have been used extensively in studies on the evolution of humans from hominidlike primates. The evolution of teeth has also been postulated by paleontologists, beginning with the study of fossils of long-extinct animals. Primitive toothlike, conical, noncalcified structures are found in lampreys. Cartilaginous fishes such as sharks have toothlike structures that are composed of solid osteodentin and that are formed at the bony surface of the jaws rather than developing within sockets. The teeth of more advanced fishes are variable in structure but are usually composed of osteodentin. Large reptiles such as alligators have developed a regular dentition with teeth suspended in sockets rather than fused to bone, and some specialization of teeth occurs, with several teeth in each quadrant being larger than the others. The specialization continues in mammals, with variations in dentition related to food requirements.

Diseases. Teeth can be affected by a variety of diseases as well as by developmental malformations. The common diseases of human dentition are dental caries, periodontal disease, and malocclusion.

Dental caries is a bacterially caused resorption or destruction of the enamel and dentin of the tooth, leading eventually, if untreated, to an infection of the dental pulp and an abscess of the apex of the tooth. The caries-causing bacteria proliferate within a protective covering, called plaque, on the tooth surfaces and produce both acid and enzymes to break down the calcified substances of the tooth. Sweets and other foods that stick to the tooth surface increase the activity of the caries-producing bacteria. Saliva, containing immunoglobulins and other antibacterial substances, tends to protect against caries, and decreased flow of saliva usually results in increased caries. Tooth shape and hereditary factors also determine a person's susceptibility to the disease.

Periodontal disease is a chronic or low-grade infection of the tissues supporting the tooth and can result in tooth loss by recession or loss of the supporting tissues. Malocclusion, or significant inability to close the teeth properly because of abnormal alignment, results in difficulty in chewing and can eventually lead to increased caries and periodontal disease. Preventive measures against the development of periodontal disease and caries include proper oral-hygiene procedures to remove plaque from tooth surfaces, and public-health procedures such as the addition of fluoride to drinking water.

See also: DENTISTRY.

Teflon Teflon, one of the earlier PLASTICS to be developed (1938), is a Du Pont trade name for the white, soft, waxy, and nonadhesive polymer of tetrafluoroethylene. Teflon has a useful temperature range exceeding 250° C (about 500° F), is inert to all chemicals except molten alkali metals and fluorine gas, and does not burn. Its electrical insulating properties and low friction are outstanding. The chemical industry uses Teflon in tubing, stopcocks, gaskets, and chemical-resistant work surfaces. It is also used for low-friction bearings and rollers and as a coating on saw blades. Cooking utensils may be coated with Teflon to prevent food from sticking.

See also: FLUORINE; FLUOROCARBON.

Tegucigalpa [tay-goo-see-gahl'-pah] Tegucigalpa, the capital of Honduras, lies in a small basin in the south central part of the country. It has a population of 551,606 (1988). With no railroad, the city depends on a road linking it with the PAN-AMERICAN HIGHWAY and on the international airport at Toncontín, 6 km (4 mi) outside the city. Manufactures include textiles, sugar, and tobacco products. An 18th-century cathedral and the University of Honduras (1847) are located there. Old Tegucigalpa, on the slopes of Mount Picacho, was founded during the 1570s as a silver- and gold-mining camp; in 1880 it became the capital of Honduras. Comayaguela, across the Choluteca River, merged with the older settlement in 1938.

Tehran [tair-ahn'] Tehran (also Teheran) is the capital and largest city of Iran. The city (1986 pop., 6,042,584) is located at an elevation of 1,200 m (3,940 ft) at the southern foot of the Elburz Mountains; snowcapped Mount Demavend is nearby.

Contemporary City. Since the overthrow (1979) of MUHAMMAD REZA SHAH PAHLAVI and the establishment of an Islamic republic in Iran, Tehran has been a city in transition. At the start of Enghlab Avenue (formerly Reza Shah Avenue) is the Shahyad Monument (1971). Built by the former shah to celebrate 2,500 years of Persian history, it is now called Freedom (*Azadai*) Monument. Hosseineh Mosque, closed down by the former regime, has been reopened as an Islamic training center with an extensive Islamic library. The Reza Shah Pahlavi Mausoleum has been renamed the Center for Islamic Studies and converted to religious use. Gulestan, Marble (Marmar), and Saadabad palaces are now maintained by the new regime to illustrate the opulence in which the former royal family lived. Old Shanhashani Park on Mosaddeq Street (formerly Pahlavi Street) has been renamed Melaat Park. In this same area of the lower city, in a labyrinth of narrow, covered alleys, are the famous bazaars of Tehran, a myriad of small shops and stalls. The city's two major universities are the University of Tehran (1934) and the National University (1960).

The majority of Tehran's inhabitants are both Muslim and Persian. Before the revolution Tehran was the focus of Iran's industrial-modernization program. The city continues to produce about half of the country's manufactured goods. Numerous banks and insurance companies are located in the city. A petroleum refinery and an auto assembly plant are nearby.

History. The city of Tehran stands near the site of the former Iranian capital of Rey, which was destroyed by Mongols in 1220. The nearby village of Tehran was fortified in the 16th century, and since 1788 it has served as the capital of Iran. During the 19th century Tehran had a population of 120,000. The city's vast modern expansion began under REZA SHAH PAHLAVI (r. 1925–41). By 1939 the population of the city had reached 500,000, and by 1960 it was 2,000,000.

Tehuacán Valley [tay-wah-kahn'] Large-scale archaeological investigations conducted during the 1960s and '70s in the Tehuacán Valley, in the semiarid highlands of Puebla, Mexico, have revealed a continuous cultural sequence extending from before 7000 BC until after the Spanish conquest. The 456 known sites range from tiny early camps to Coxcatlán, the large town that dominated the valley during AZTEC times. Tehuacán's dryness has favored the preservation of normally perishable materials that provide unique evidence concerning the processes by which village farming developed in MESOAMERICA. The first inhabitants of Tehuacán were small, roving bands of food collectors. After 7000 BC plants were cultivated, gradually increasing in number and in the importance of their contribution to the diet. By 1000 BC the people of Tehuacán occupied settled village communities and raised the bulk of their food.

Tehuantepec, Isthmus of [tay-wahn-tay-pek'] The Isthmus of Tehuantepec is the narrowest part of Mexico, between the Gulf of Mexico and the Pacific Ocean. About 220 km (140 mi) wide, it is crossed by a railroad. The northern half, part of the state of Veracruz, is swampy and tropically humid. The drier southern half, part of the state of Oaxaca, produces sugarcane, sorghum, and corn.

Tehuelche [tuh-wel'-chee] The Tehuelche Indians, whose language was related to the Araucanian linguistic family, formerly roamed the grasslands of Patagonia in pursuit of guanaco and smaller game, moving from one water hole to another and living in small patrilineal bands of about 100 members each. They lived in *toldos*, animal-hide lean-tos, which they carried with them. They did not practice agriculture and had no domesticated animals except dogs. Shamanistic religious practice prevailed. The Tehuelche population probably never exceeded several thousand.

The simple organization of the Tehuelche changed radically after the arrival of the Spaniards (from 1520 on) introduced horses into Patagonia. The Tehuelche first hunted horses, then learned to ride them, after which they were able to increase their hunting territory. This led them into conflict with Indians of the Gran Chaco, who had also acquired horses and had begun to extend their territories. Military chieftainship developed, and predatory raiding supplanted hunting. By the late 19th century traditional life had waned, and the Tehuelche were gradually absorbed into the gaucho population of Argentina.

teiid [tee'-id] Teiids are lizards found only in the New World, mostly in warm areas. About 200 species, classified in 40 genera, make up the family Teiidae, thought to be the counterpart of the Old World LACERTIDS. Teiids, which characteristically have deeply forked tongues and conical front teeth and lack osteoderms, or bony skin plates, are a very diverse group. Some—the microteiids (subfamily Gymnophthalminae)—are generally small and have the anterior nasal scales separated by frontonasal scales. Some of these species are burrowers with degenerate limbs. Other teiids—the macroteiids (subfamily Teiinae)—are typically medium-to-large lizards and have the anterior nasal scales intact. These species are mostly terrestrial or semiaquatic and have well-developed limbs. The RACE RUNNERS (genus *Cnemidophorus*), ranging from the southern United States through South America, are known for their long, whiplike tails and speed.

Teilhard de Chardin, Pierre [tay-ahr' duh shahr-dan'] The theologian and paleontologist Pierre Marie Joseph Teilhard de Chardin, b. May 1, 1881, d. Apr. 10, 1955, was a French Roman Catholic priest who developed a religiously oriented doctrine of cosmic evolution. He became a convinced evolutionist, and he spent his life attempting to show that the acceptance of evolution does not involve the rejection of Christianity. His efforts to convince the church that it should accept the implications of the Darwinian revolution met such powerful resistance that in 1926 he was removed by his superiors from the Institut Catholique in Paris, where he had been a lecturer.

For the next 20 years Teilhard lived in China, where he was involved in paleontological research that led to the discovery of PEKING MAN, and also completed his major work, *The Phenomenon of Man* (1955; Eng. trans., 1959). Despite numerous applications to Rome, he was not allowed to publish writings other than scientific studies, with the result that none of his religious works appeared until after his death.

Pierre Teilhard de Chardin was a French Roman Catholic priest whose doctrine of cosmic evolution stirred much controversy. Teilhard argued that as evolution becomes more complex, it converges into one unified end point, Jesus Christ.

Teilhard believed that all matter is profoundly historical. Long before the emergence of living things, nonliving matter was subject to a law of complexification, resulting in a continuing, irreversible drift toward increasingly complex organization. The latest creature to emerge from this process is humankind, with its capacity for self-conscious thought.

Humans as they are now known are not the end of the process, he asserted. Everything that arises converges. Widely different human cultures around the Earth are now converging toward an omega point, identified by Teilhard as Christ, at which consciousness can find a new unity.

teju [tuh-zhoo'] The tejus, or tegus, genus *Tupinambis*, are large, fast-moving lizards of the family Teiidae. They inhabit tropical and subtropical regions of South America, where they feed on insects and small vertebrates, soft fruits, leaves, and birds' eggs. They measure 60 to 90 cm (2 to 3 ft) long and have powerful legs and long tails. The teju lays its eggs, usually six to eight in a clutch, in termite mounds, which serve as perfect incubators with well-regulated temperature and humidity.

Tekakwitha, Kateri [tek-ahk-with'-uh] The first North American Indian proposed for canonization by the Roman Catholic church, Kateri Tekakwitha, b. near Auriesville, N.Y., 1656, d. Apr. 17, 1680, was the daughter of a Mohawk chief. Her Algonquin mother and her father died in a smallpox epidemic when she was 4 years old, and she was later instructed and baptized by a Jesuit missionary. She was revered for her kindness, faith, and endurance of suffering. Documentation for her canonization was introduced in 1932, and she was beatified in 1980.

tektites Tektites are naturally occurring glass objects containing 70% to 80% silicon dioxide. They are spheroidal to tear shaped and are black or green in color. The objects are found scattered across areas, called strewn fields, in Australia, Indonesia, Southeast Asia, the Philippines, Czechoslovakia, West Africa, Texas, and Georgia. Tektites less than a millimeter in diameter, called microtektites, are found in cores of young marine sediments near some fields.

The origin of tektites is controversial. The pits and grooves on their surfaces indicate that they were once molten, and their shapes indicate that they were aerodynamically molded by flight through the Earth's atmosphere. Their chemical compositions are similar to those of some terrestrial igneous and sedimentary rocks. This had led to the widely held theory that tektites were formed when large celestial objects such as comets or asteroids struck the Earth's surface. Droplets ejected by the impacts were then shaped by high-speed flight through the atmosphere.

Some geologists instead propose that tektites are no more than about 10,000 years old and are fragments of materials ejected by eruptions on the Moon.

Tel Aviv–Jaffa [tel uh-veev'-jah'-fuh] Tel Aviv, Israel's second largest city, is located on the Mediterranean coast of Israel, about 55 km (35 mi) northwest of Jerusalem. The municipality has a population of 317,800 (1989 est.); the larger metropolitan area (the Tel Aviv District), spreading over 170 km^2 (66 m^2), contains 1,032,200 people (1989 est.).

Contemporary City. A predominantly modern city, Tel Aviv–Jaffa presents a skyscraper facade along Ha-Yarkon Street, which fronts the coast and contains the city's major hotels. The leading commercial enterprises are located to the east. The ancient port area of Jaffa is medieval in appearance.

The economic, financial, commercial, and cultural center of Israel, Tel Aviv–Jaffa is also a transportation hub and the main center of the nation's tourist trade. Tel Aviv–Jaffa—and Israel—are connected to the rest of the world via the international airport at Lod, 14 km (9 mi) southeast of the city; the port of Ashdod, 31 km (19 mi) to the south; and the port of Haifa, 80 km (50 mi) to the northeast.

The location of about 50% of Israel's industrial plants in Tel Aviv–Jaffa makes it the country's principal manufacturing center. Industries include textiles, chemicals, metals and engineering products, vehicles, electric and electronic equipment, furniture and wood products, food and tobacco processing, diamond polishing, and printing and publishing. The Tel Aviv stock exchange is Israel's only such institution, and most banks, insurance companies, and other large corporations are headquartered there.

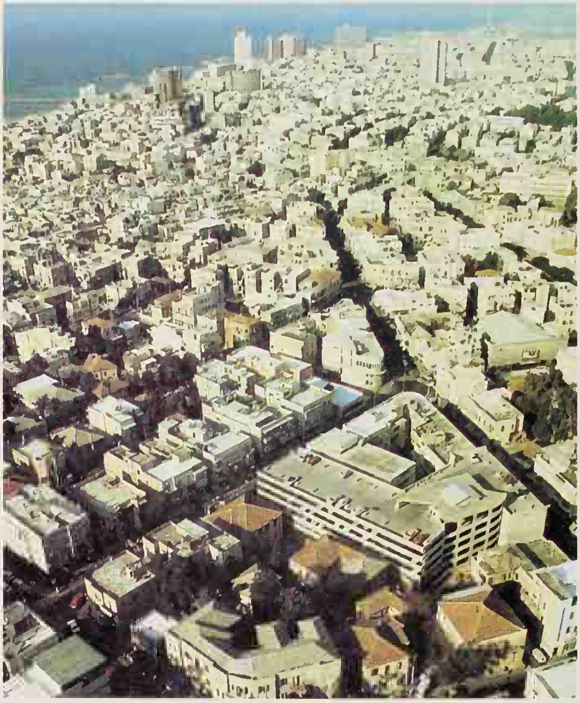
Tel Aviv–Jaffa is the home of Bar-Ilan University (1953) and Tel Aviv University (1953), as well as of the Israeli national theater, Habimah, and the Israel Philharmonic. The Tel Aviv Museum, the Ha'aretz Museum, the Museum of the Diaspora, and a zoo add to the cultural life of the city.

History. The growth of the city, after its founding in 1909 as a Jewish suburb of the largely Arab town of Jaffa, was sparked by the issuance of the Balfour Declaration (1917), by the anti-Jewish rioting in Jaffa (1921), and by the rise of Nazism in Germany. The independence of Israel in 1948 was followed by a population increase in Tel Aviv of more than 60% within the next 4 years, as well as by the departure of virtually all the 65,000 Arab residents of Jaffa, which was incorporated into Tel Aviv in 1949.

The city served (1948–49) as the temporary headquarters for the provisional government of Israel. It remains the headquarters of Histadrut, the Israeli Ministry of Defense, some foreign embassies, and several political parties. Tel Aviv–Jaffa is governed by a council elected for a 4-year term.

During the 1991 GULF WAR, Tel Aviv–Jaffa was hit by Iraqi scud missiles as Iraq attemped, unsuccessfully, to draw Israel into the conflict.

Tel Aviv, the second largest city and industrial center of Israel, lies along the eastern shore of the Mediterranean Sea.

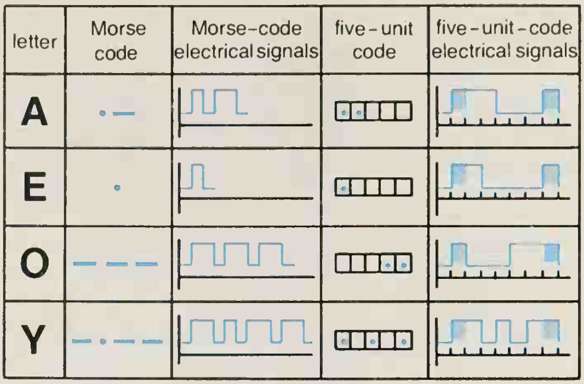


telecommunications Telecommunications refers to long-distance communication (the Greek *tele* means "far off"). At present, such communication is carried out with the aid of electronic equipment such as the RADIO, TELEGRAPH, TELEPHONE, and TELEVISION. In earlier times, however, smoke signals, drums, light beacons, and various forms of SEMAPHORE were used for the same purpose (see SIGNALING). The information that is transmitted can be in the form of voice, symbols, pictures, or data, or a combination of these. Data communication is a rapidly growing part of telecommunications. The physical equipment for a telecommunications system includes a TRANSMITTER, one or more RECEIVERS, and a channel or means of communication such as the air, wire, CABLE, COMMUNICATIONS SATELLITE, or some combination of these. By a process called multiplexing, several different signals can be transmitted over a single channel (see MULTIPLEXER). The carrier signal is divided into separate subcarriers, each of which can be modulated by a different signal (see MODULATION). At the receiving end of the system, these signals can be separated from the carrier and distributed as needed.

Today it is possible to mix together different forms of information—speech, music, video signals, business data—and send them over the same carrier signal. Using a method known as pulse-code modulation (PCM), for example, the information is sent as a series of on-off pulses. The transmission is digital in form, so greater accuracy is maintained (see DIGITAL TECHNOLOGY). A long-distance analog signal is subject to a loss of quality; a digital signal, however, is likely to be interpreted correctly, because it is simply a series of on-off signals. Another advantage of PCM is that pulse signals can be compressed to a remarkable degree, thus increasing transmission capacity.

Another way of increasing channel capacity is to use for the carrier wave ELECTROMAGNETIC RADIATION of higher frequency than radio frequencies. MICROWAVES have greater carrier capacity than radio waves. FIBER OPTICS makes use of light waves, which have even greater capacity. Light provides carrier waves having a frequency of 10^{14} hertz (cycles per second), which is 10,000 (10^4) times higher than microwaves and 10^8 times higher than radio waves. A single glass fiber measuring 0.013 cm (0.005 in) in diameter can replace 10,000 telephone wires. Fiber-optic transmission of telephone conversations is now used in many U.S. telephone systems.

Engineers and planners in telecommunications look forward to a time in the near future when telephone, computer, facsimile (FAX), television, and even mail will be linked together in a single electronic system, which has been named the Integrated Services Digital Network (ISDN). ISDN is an evolving system of international standards that will eventually provide high-speed digital voice and data transmission over existing telephone wiring.



letter	Morse code	Morse-code electrical signals	five-unit code	five-unit-code electrical signals
A	· —		●●○○○	
E	·		●○○○○	
O	— — —		○○○●●	
Y	— · — —		●○●○●	

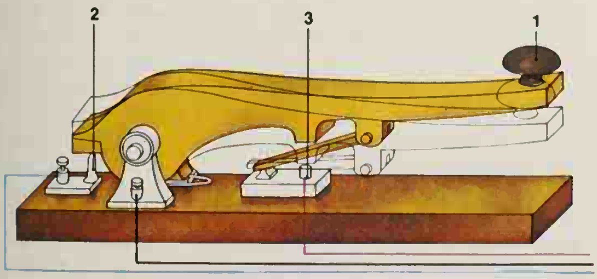
Morse code is used in manual telegraphy. Letters of the alphabet are transmitted as combinations of long and short pulses of electric current according to an internationally accepted system of dots and dashes. Automatic operation of teletypewriters or other machines requires the use of a special binary Murray code in which groups of five signals are sent (dots) *or not sent* (spaces).

telegraph For most of human existence, only visual and acoustic methods of signaling were available, as in the use of beacon fires or the sounds from church bells. By the early years of the 19th century, however, it became possible to use an electric current to communicate between two separated stations.

History

During the early 19th century the transmission of a message by telegraph was simple: a switch, or key, could be used by the operator to supply short pulses of electric current to the wire (line) from a battery; the circuit was completed through the earth. The pulses could be dispatched in time patterns forming codes representing the letters and numbers that formed the message. The problem of how to detect the current pulses at the remote receiving station was solved in 1819, when Hans C. Oersted discovered that a wire carrying an electric current deflected a magnetic needle, the sense of the deflection being reversed with reversal of the direction of flow of the current. Deflecting-needle telegraphs, also known as electric telegraphs, were investigated by many scientists, but the most successful instrument was that of William F. Cooke and Charles Wheatstone, who installed the first railway telegraph in England in 1837.

A Morse two-pole telegraph key is essentially a switch for opening and closing an electric circuit between two telegraph stations. When the transmission line (red) *is not in use, current flows from the power line* (black) *through a bypass line* (blue). *Depressing the key* (1) *breaks the bypass contact* (2), *and a current pulse is sent through the transmission-line contact* (3).



The invention of the electromagnet by William Sturgeon in 1825 and the researches of Michael Faraday and Joseph Henry on electromagnetic phenomena about 1831 stimulated Samuel F. B. MORSE to devise a telegraph receiver. In the receiver an electromagnet, energized by the pulse of current from the line, attracted a soft iron armature; this action produced deflection in the straight line being scribed on a moving strip of paper by a pencil carried by the armature. Morse, along with Alfred Vail, greatly improved this receiver and adapted it to print the dot and dash symbols of MORSE CODE, which Morse had invented for the representation of alphanumeric characters. The two symbols corresponded to pulses of short and long duration, respectively. In 1844, Morse successfully demonstrated this magnetic telegraph by sending the message "What hath God wrought" from Baltimore to Washington. Morse's receiver was widely adopted.

Signaling distances were greatly improved by the use of a relay, an electromagnet receiver that used the feeble current from the line to operate a switch that provided local battery power to key a further length of telegraph line. The thermionic TRIODE tube, which was invented in 1907, was also used to amplify telegraph signals. Utilization of the early telegraph lines was also increased by the invention of devices to permit duplex working, transmission of signals in opposite directions simultaneously over the same line, and also diplexing, the transmission of two signals simultaneously in the same direction. The combination of diplex with duplex by Thomas Alva Edison in 1874 created quadruplex.

The rapid growth of commercial telegraph traffic stimulated the development of other methods to increase the speed of handling of signals. One solution was the development of a tape-reader machine, which transmitted Morse signals at high rate in accordance with a message that was expressed as a sequence of holes in a perforated tape. Wheatstone produced such a system in 1858, which operated in association with a Morse inker to print the received signals on a moving tape. The received Morse signals were inscribed by an undulator and had to be read by an operator, who typed or wrote the message. By these improvements speeds of up to 400 words per minute were achieved by 1900. Many of these devices also found application in radio telegraphy, which was introduced by Guglielmo Marconi in 1897, and in submarine telegraphy, which was in use as early as 1851.

Multiplex System

The time division, or multiplex, system of telegraphy, perfected by Émile Baudot in 1874, increased the traffic capacity of a line. Instead of Morse code, a five-unit code was used in which every character contained five symbol elements, each being of equal duration and designated as a mark or a space according to the provisions of the code and corresponding to current on and current off, respectively. Five keys were available to the operators, who set up the units of the character to be transmitted. A modified form of Baudot's five-unit code was ultimately adopted as the International Telegraph Alphabet No. 2. In this alphabet, the letter *P*, for example, is represented as three perforations on a transmission tape located in this way: | |·|·| |· —a 01101 in binary characters. Baudot's system continued in use, particularly in Europe, until well into the 20th century.

Carrier Telegraphy

The versatility of thermionic tubes as generators, amplifiers, and detectors of signals ultimately led to the abandonment of all electromechanical multiplex systems and achieved the virtual coincidence between the techniques employed in the telegraph and telephone systems. The telephone was invented by Alexander Graham Bell in 1876, after which telephone service developed rapidly in the United States and in most of the countries of Europe. Although the telephone at first posed a commercial threat to the telegraph, the fact that the two instruments fulfilled complementary rather than competing functions was soon recognized. The growth of telephone networks in fact, stimulated the development of new techniques in telegraphy, such as voice-frequency telegraph channeling systems that carried up to 24 telegraphy channels in a single telephone channel.

The signaling element of the simple telegraph is a direct-current (DC) pulse corresponding to the dot or dash of the Morse code or the signals of the five-unit code. In the carrier system, a voice-frequency, alternating current (tone) is modulated by the sequence of DC pulses that constitute the message. One such tone provides a single telegraph channel; a number of tones, however, are employed equally spaced in frequency to fill a voice-frequency channel covering approximately 350 to 3,200 Hz. This band of telegraph carriers, in association with a number of similar telegraph bands as well as telephone channels, are impressed on a single high-frequency carrier that is carried by a single transmission line. The channels are separated at the receiver, and the telegraph signal from a particular carrier is extracted.

The Teletypewriter

The increase in traffic that the carrier telegraph system stimulated caused a great increase in the number of terminal stations and therefore led to the development of the teletypewriter for the transmission and reception of telegraph messages. A teletypewriter possesses a typewriter keyboard; the depression of a key supplies the correct sequence of impulses directly to the telegraph line in accordance with the five-unit code. In addition, the pulses, both outgoing and incoming, activate the machine to print the messages in typescript. The combination of carrier telegraphy and teletypewriter terminals has resulted in enormous growth in the national and international telegraphy networks and in the associated telegraph switching centers that form the modern Telex system.

Telemann, Georg Philipp [tel'-uh-mahn] The German composer and organist Georg Philipp Telemann, b. Mar. 14, 1681, d. June 25, 1767, was regarded during his lifetime as one of Germany's greatest musicians. He held a series of important musical positions, culminating in that of music director of the five largest churches in Hamburg, from 1720 until his death. Telemann's contrapuntal skill, melodic facility in the Italian style, French elegance, and fertile imagination resulted in music that was fluent but often lacking in depth. His amazing productivity resulted in 12 cycles of cantatas for the entire church year. He also composed huge quantities of chamber music; many concertos, and solo harpsichord and organ works; about 600 orchestral suites; and 40 operas.

telemetry [tuh-lem'-uh-tree] The word *telemetry* refers to communications systems that make measurements at remote or inaccessible points and transmit these measurements to receiving equipment where they are monitored, recorded, and displayed. Telemetry's major uses include monitoring electric generating stations, gathering meteorological and oceanographic data, and monitoring spaceflights and body conditions. Telemetric systems consist of a measuring-transmitting instrument, a medium of transmission, a receiver, and recording or display equipment. The measuring-transmitting instrument is usually a transducer, which converts physical stimuli into electrical signals.

A line is employed in short-distance telemetry or where radio transmission is expensive or impractical, such as in a large city. For aerospace applications and transmission over long distances, radio is used. The radio signal may carry at one time several types of information, which are combined into a single signal and transmitted by a device called a MULTIPLEXER. Sonic and light-telemetry-transmission systems are still in the experimental stage. Telemetry-receiving equipment extracts the data from the signal and presents it in usable form. Data may be displayed on a screen, recorded on magnetic tape, or automatically typed and printed out on a sheet of paper.

teleology [tee-lee-ahl'-uh-jee] Teleology is the study of things or events in terms of their purposes or ends. From ancient times to the present, many philosophers and scientists have thought that various natural processes could be explained only in terms of the purposes that they were achieving or in terms of the ends or goals that they were reaching. In ARISTOTLE's physics, four types of explanation were offered, but the most important one was in terms of the purpose (Greek: *telos*), or final goal, of physical change. For Aristotle all processes of change were purposeful.

In the development of modern science, one of the first contentions of Galileo Galilei and René Descartes was that purposes could neither be known nor discovered. Although scientists have progressively removed teleological inquiry from one branch of the study of nature after another, the central issue remains: whether teleological explanation is necessary to account for the behavior of living or conscious beings or whether all of their behavior can be explained without it.

teleost [tel'-ee-ahst] A teleost, subclass Teleostei, is a bony FISH with rayed fins. The vast majority of familiar fishes are teleosts, with between 18,000 and 25,000 species now recognized and new species being identified each year. The several major groups include the Osteoglassomorpha, a primitive freshwater group that includes bonytongues and mooneyes; the Elopomorpha, a primarily marine group including true bonefishes, EELS, and TARPONS; the Clupeomorpha, or herringlike fishes (see HERRING); and the Euteleostei, or higher teleosts, including the CARP, CATFISH, CHARACIN, COD, PIKE, SALMON, TROUT, and many perchlike species (see PERCH).

telepathy see EXTRASENSORY PERCEPTION

telephone The telephone is a device for reproducing sound at a distance from its source by means of the transmission of an electrical signal. There are more than 500 million telephones worldwide, with over 190 million in the United States alone.

Basic Principles. The telephone now in use is similar to the original device patented by Alexander Graham BELL in 1876 and 1877. Because sound waves do not travel very far (or very fast), there were many attempts to devise systems like the telephone, in which the sound waves are converted into electrical oscillations, which can be sent long distances and are then converted back into sound waves at the receiving end. Aided by Thomas A. Watson, Bell succeeded in developing a practical telephone. Although a vast number of improvements have been made in Bell's original system, the basic principles—using voice vibrations to control a larger source of power and creating a variable resistance in an electrical circuit—remain the same. In a modern telephone the speaker talks into the mouthpiece, behind which is a transmitter. Vibrating air molecules produced by the speech generate vibrations in a thin aluminum diaphragm. These vibrations are transmitted to a small piston, which is the cover for a metallic box filled with small granules of carbon. Electrical contact is made only through the carbon, which is a reasonably good conductor of electricity. Vibration of the membrane/piston causes the electrical resistance of the carbon grains to vary. Changes in resistance result in variations in the amount of electricity passing through the circuit, and hence the connecting line.

In 1877, Alexander Graham Bell, the Scottish-American inventor of the telephone, lectured about his invention to an audience in Lyceum Hall, Salem, Mass. During his lecture he demonstrated that he could converse by telephone with his assistant, Thomas A. Watson, 29 km (18 mi) away in Boston.

At the receiving end (the earpiece), a second membrane is made to perform vibrations similar to the ones induced in the first one. This is accomplished by causing it to be variably attracted by a wire-wound iron core, or electromagnet, where the wire is part of the circuit. As the current in the circuit varies, the membrane vibrates with the same wave pattern as the transmitter membrane, thus reproducing the original sound.

The telephone must operate as part of a complete electric circuit, and so it needs a power source, a conductor, and a switch. The power source is electricity; the conductor in the basic system is the pair of wires that lead from the transmitting and receiving telephones to the central office; and the switch is the cradle or pair of buttons that moves when the user picks up the handpiece. Lifting the handpiece closes an electric circuit to produce a dial tone, which indicates that the system is ready for a call to be made. The dial (or, in a touch-tone phone, the panel of buttons) sends out an electrical code that establishes the correct connections needed to single out the other telephone that is dialed from the many millions connected to the system.

Switching Systems. In the first commercial system, manual connections were made in central switching offices by operators at manual switchboards. Today the vast majority of switching is done automatically, at least in the technologically advanced countries. Through a system called Direct Distance Dialing, it is possible for almost all Americans to dial almost anywhere in the country. From most exchanges it is even possible to dial overseas calls. For each call a series of electromechanical selector switches, called relays, automatically move into the correct positions. Modern switching equipment makes the needed connections in a few seconds and also routes the signal around crowded exchanges.

In many cities, CELLULAR RADIO networks are set up to provide automatic switching for portable telephones carried by automobiles. In such a system, a phone on the move is repeatedly transferred to the transmitter of the next local "cell," thereby maintaining a constant service.

Electronic switching systems using computers can be set up to provide additional services; for example, such systems can automatically forward calls, add a third party to a call, and alert a caller when another call is waiting.

Carrier Systems. Telephone messages are sent bunched together over trunk lines, increasing the number of conversations that can be carried by any one conductor. The signals that contain the information being transmitted are carried by high-frequency waves. Generally, the wider the bands of frequency that are used as carriers, the more information they can handle.

Telephone signals are transmitted by copper telephone wire—the most common transmission form—or by cable, radio relay, microwaves, and, most recently, optical fiber lines (see FIBER OPTICS). The advantages of fiber transmission include greater data capacities and higher transmission speeds. The fibers are lighter than copper wire and are not easily affected by stray magnetic fields. COMMUNICATIONS SATELLITES transmit overseas, ship-to-shore, and plane-to-shore telephone messages. Mobile cellular phones make use of radio waves.

Digital Systems. As telephones have become more and more central to the transmission of messages and data from such digital devices as computers, and as the use of telephones themselves has increased, it has become necessary to find better, faster methods of transmission than the analog systems presently used. Digital telephone systems take rapid samplings of sound and translate them into signal pulses carrying digital one/zero codes. Digitizing will permit the creation of digital networks, allowing communications between computers, for instance, and between digital systems within and among businesses, factories, and other organizations. A complete, high-speed nationwide and worldwide TELECOMMUNICATION system is dependent on digitized phone systems.

In order to digitize telephone systems, the electromagnetic or electronic switches in central exchanges must be replaced by digital switches, a process that has already been begun by many telephone companies. They provide faster switching, more accurate transmission of sound, and such features as the automatic transfer of calls and itemized customer bills.

Extended Uses. During the 1920s, news associations began to send pictures over specially built telephone lines. In 1924, telephone wires carried the first coast-to-coast radio broadcast, and in 1927 the first experimental long-distance television transmission was demonstrated at Bell Laboratories. Teletypewriter-exchange service, wherein typed messages are sent between machines interconnected through switching centers, like telephones, was introduced in 1931. Today the virtues of all-digital telephone systems are illustrated by, for example, the phenomenon of COMPUTER NETWORKING and by the existence of Local Area Networks (LANs).

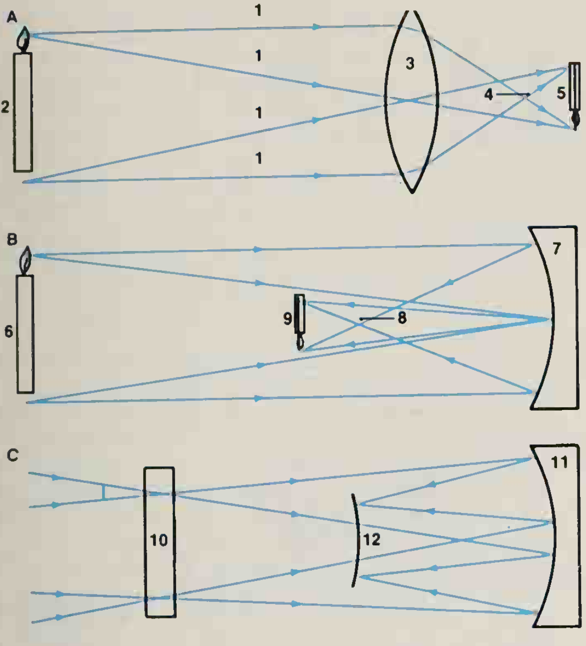
Research in telephones has produced sound motion pictures, the transistor, electrical recording of phonograph records, and optical communications.

The Telephone Industry. The American Telephone & Telegraph Company (AT&T) was formed in Boston on July 9, 1877, as the Bell Telephone Company by the inventor Alexander Graham Bell and two financial backers. For two years the company had to compete with the Western Union Telegraph Company, which had hired Thomas Alva Edison to develop a different form of telephone transmitter so that it would not have to use Bell's invention. The competition ended in 1879 when Bell Telephone brought a successful suit against Western Union for infringement of its patents. The company moved to New York City in 1885 and was reorganized as AT&T, with the Bell System as one of its subsidiaries.

Although the Bell patents expired in 1894, AT&T soon bought up most prospective competitors, won control of about 85 percent of the U.S. telephone market, and became linked with corporate and government telephone systems around the world. After 1934 its activities were regulated by the Federal Communications Commission (FCC).

From 1974 to 1982, AT&T was involved in an antitrust suit brought against it by the U.S. Department of Justice. Presided over by Judge Harold H. Greene, the case resulted in a massive reorganization of the U.S. telephone industry. AT&T was forced to relinquish its 22 Bell System companies, as well as the Bell name. The 22 operating companies were reorganized under the control of 7 regional telephone companies and continued to offer local telephone service. AT&T was allowed to maintain its long-distance telephone business. While AT&T is now becoming a diversified, high-technology business, it is finding itself in serious competition both with other long-distance telephone companies and with makers of telephone equipment. Newer long-distance companies include MCI Communications and GTE Corporation.

telescope, optical An optical astronomical telescope is an instrument that is used to collect light from a celestial object, to bring the light to focus and produce an image, and to magnify that image. The two main types of telescopes are refractors, which use lenses, and reflectors, which use mirrors. The main lens or mirror that focuses the light is called the objective. Both telescopes have an eyepiece, or combination of small lenses, to magnify the image formed by the objective. In addition, the



In a refracting telescope, or refractor (A), *light rays* (1) *from an object* (2) *pass through a lens* (3), *are bent, or refracted, to a focal point* (4), *and form an inverted image* (5). *In a reflector* (B), *light rays from the object* (6) *are reflected by a concave mirror* (7) *to a common focus* (8) *and form an inverted image* (9). *In a Schmidt telescope, or camera* (C)*—because it is used only for photographic work—an aberration-free wide field of view is obtained by use of a spherical mirror and a correcting lens. Light from an object passes through a thin lens, or corrector plate* (10), *and is reflected from the spherical mirror* (11) *to a curved focal surface* (12), *which holds the photographic film.*

reflector telescope uses a small secondary mirror to reflect the light from the main, or primary, mirror to a convenient position for placement of the eyepiece or of auxiliary equipment, such as a photometer or spectrograph. In general, refractor telescopes are used for lunar and planetary studies, as well as for astrometric work involving precision measurements of double stars and stellar proper motions. Reflector telescopes are preferred for extragalactic studies, photography of faint objects, photometry, and spectrographic work.

A third type of telescope—a catadioptric telescope—uses a combination of lenses and mirrors to obtain the advantages of both the refractor and the reflector. The most famous of this type is the Schmidt telescope, developed (1934) by the German optician Bernhard Schmidt.

The optical instruments described in this article are used to observe and photograph objects in the visible region of the electromagnetic spectrum, ranging into the near-infrared and ultraviolet regions as well. For work in other regions of the spectrum, different forms of devices are used to perform equivalent functions, such as the parabolic antennas of radio astronomy (see gamma-ray astronomy; infrared astronomy; ultraviolet astronomy; X-ray astronomy).

History

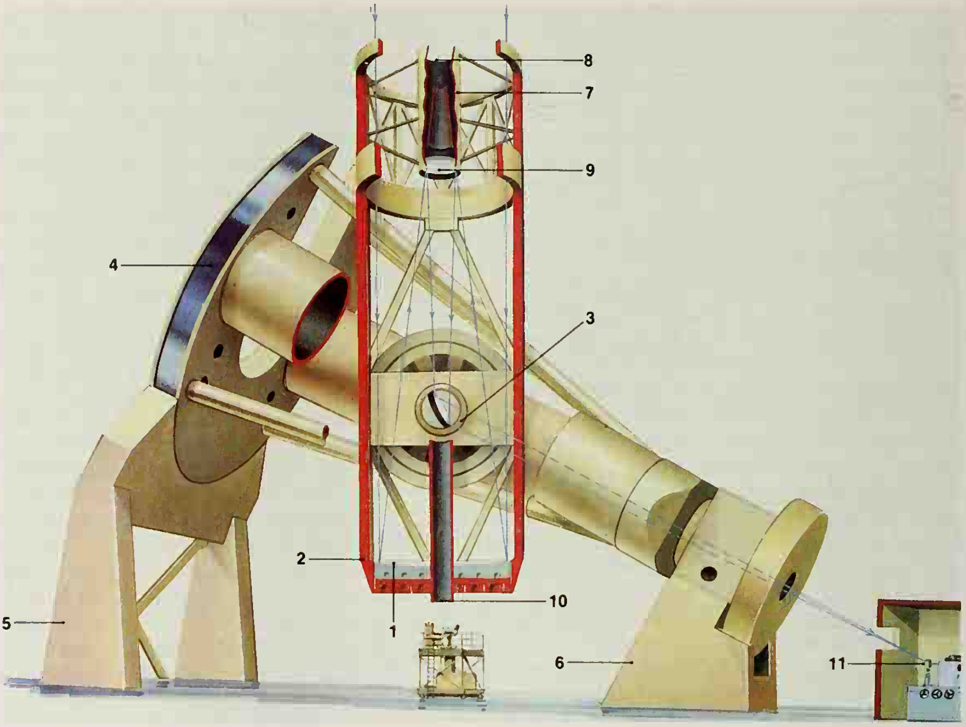
Tradition attributes the invention of the telescope to the accidental alignment of two lenses of opposite curvature and diverse focal length by Hans Lippershey in Holland in 1608. The principle, however, may have been known to Roger Bacon in the 13th century and to the early spectacle makers of Italy.

Refractors. Galileo Galilei constructed (1609) the first lens, or refracting, telescope for astronomical purposes. Using several versions, he discovered the four brightest Jovian satellites, lunar mountains, sunspots, the starry nature of the Milky Way, and the apparent elongation of Saturn, now known to be its rings. Galileo's simple lenses suffered from a variety of aberrations, or defects of image formation: chromatic aberration, or the variation of focal length (see lens) with color; spherical aberration, the variation of focal length with distance of parallel rays from the lens axis; coma, the increasing blur of a point image as the angle of the rays to the axis increases; and distortion, the imaging of straight lines in the object as curves (see aberration, optical). These aberrations were minimized in a variety of ways. Christiaan Huygens constructed extremely long aerial telescopes in which the objective lens was mounted on a pole and connected to the eyepiece by only a taut wire. Despite extraordinary difficulties, such instruments achieved useful results, especially in lunar mapping.

The 18th-century London optician John Dollond combined (1757) a convex crown glass and a concave dense flint to make a compound lens that compensated for the chromatic aberrations at two wavelengths. Two-component lenses of increasing sophistication have since been developed, and today computer programs exist for the design of lens systems with multiple components.

The largest visual refractors are at Lick Observatory (36 in/91 cm) and Yerkes Observatory (40 in/102 cm). The size of refractors is limited by the difficulty of making large defect-free glass blanks and by the distortion caused by the sagging of the lens under its own weight.

Reflectors. In England in the 17th century, attention turned to mirror, or reflecting, telescopes. Isaac Newton proposed (1668) a telescope in which a primary parabolic mirror reflects light rays to an inclined flat (in small instruments, a totally reflecting prism) placed centrally in the tube; this flat in turn reflects the rays to an observer located at the side of the upper end of the tube. An original instrument built by Newton still exists at the Royal Society of London. Many large- and medium-sized reflectors are Newtonian in design, although for diameters less than 1 m (3.3 ft) the weights of instrumentation capable of being carried far from the support axes are small, and for larger-diameter instruments elaborate carriages are needed to give an observer access to the focus. For large Newtonians the focal ratio—the ratio of aperture size to focal length—is typically near f/4. In some cases—the Hale 200-in (5.1-m) telescope at Palomar Observatory and the 120-in (3.0-m) telescope at Lick Observatory, for instance—only a single mirror is used, and access to the prime focus is from a central cage containing the observ-



The Hale reflector is located on California's Palomar Mountain. The 455,000-kg (500-ton) telescope has a 200-in-diameter (508-cm) aluminized Pyrex glass mirror (1) *with a focal length of 16.8 m (55 ft). The mirror is mounted in a tube* (2) *that moves about the declination axis* (3) *within a yoke* (4). *The yoke, which forms the polar axis, turns on oil-pad bearings on the northern* (5) *and southern* (6) *piers. A 1.5-m (5-ft) cage* (7) *provides space for an observer at the prime focus* (8) *and contains the coudé and Cassegrain secondary mirrors* (9). *The focal lengths are 80.2 m (263 ft) at the Cassegrain focus* (10) *and 150 m (492 ft) at the coudé focus* (11). *The telescope is housed in a 42-m-diameter (137-ft) dome.*

er. Some large telescopes, such as the 158-in (4-m) Kitt Peak National Observatory and the 153-in (3.9-m) Anglo-Australian telescope, carry observers at the Cassegrain focus. Except for work done at the prime focus, both old and recently built large telescopes use television viewing systems and electronic devices instead of human observers at the focus.

Early reflectors had mirrors made of speculum metal—a brittle alloy consisting of copper and tin—which required repolishing and refiguring when it became tarnished. Sir William Herschel used such mirrors for making telescopes, including one 48 in (1.2 m) in diameter. The Herschelian configuration has the main mirror slightly tilted to feed an eyepiece mounted at one side of the upper end of the tube.

Glass was first used for the manufacture of telescope mirrors in 1856, by Carl August von Steinheil and Jean Foucault; such optical surfaces were silvered by chemical processes developed by Justus von Liebig and John A. Brashear. A silver coating on glass is now superseded by vacuum-deposited aluminum and sometimes other metals by means of a technique developed in 1934. Between the world wars, glass with a low coefficient of thermal expansion (Pyrex) came into use, but since World War II such glass has largely been replaced by quartz (fused or vapor-condensed) and in some cases by special ceramics noted for their low thermal expansion.

During the 20th century several large reflecting telescopes were built on mountain sites in clear-air regions. Since World War II, telescope sizes have escalated, and instruments larger than 100 in (2.5 m) in diameter are now common.

THE WORLD'S LARGEST REFLECTING TELESCOPES

Diameter *in*	*m*	*Observatory*	*Approximate Location*	*Went into Operation*
390	9.9	Mauna Kea (Keck Telescope)	Mauna Kea, Hawaii	1991
236	6.0	Special Astrophysical (BTA Telescope)	Zelenchukskaya, USSR	1976
200	5.1	Palomar (Hale Telescope)	Palomar Mountain, Calif.	1948
176*	4.5	Mount Hopkins (Multiple Mirror Telescope)	Amado, Ariz.	1979
158	4.0	Cerro Tololo Inter-American	La Serena, Chile	1975
158	4.0	Kitt Peak National (Mayall Telescope)	Tucson, Ariz.	1973
153	3.9	Siding Spring (Anglo-Australian Telescope)	Coonabarabran, New South Wales, Australia	1974
150	3.8	Mauna Kea (United Kingdom infrared telescope)	Mauna Kea, Hawaii	1978

* The six 72-in (1.8-m) mirrors of the Multiple Mirror telescope used in concert have the light-gathering equivalent of a single mirror of this size.

Optics and Mechanics

Visual telescopes perform the functions of light gathering, magnifying, and increasing resolving power.

Light Gathering. The light-gathering power of a telescope is its ability to see faint objects as compared to the ability of the dark-adapted human eye. It is directly proportional to the square of the diameter of the telescope objective. For example, a star viewed by the giant Hale telescope at Palomar Observatory appears approximately one million times as bright as it does to the naked eye.

Magnification. Magnification is the increase in apparent angular size of an object when viewed through a telescope, as compared to the object's apparent size when viewed by the naked eye. Telescope magnification is computable as the ratio of the objective's focal length to the focal length of the telescope's eyepiece. Usually a telescope has several eyepieces for varying the magnification as desired.

Resolving Power. A telescope's resolving power is defined as the minimum angular distance it can determine between two stars of moderate brightness under ideal viewing conditions. This minimum distance, measured in RADIANS, is equal to the ratio of the wavelength of the light to the diameter of the telescope's objective. Magnification must be sufficiently substantial to compress the emerging rays to the size of the pupil of the eye, but not so large that the apparent scale greatly exceeds the angular resolution.

Lenses. Simple telescopes of the Galilean type produce erect images, whereas astronomical-type telescopes produce inverted images. Terrestrial eyepieces containing several lenses also produce erect images. Two-lens eyepieces, such as those made by Christiaan Huygens, the British optician Jesse Ramsden, and the German manufacturer Carl Zeiss, improve the correction of aberrations and increase the field of view; a Ramsden eyepiece with an achromatic lens is known as a Kellner eyepiece.

Mountings. Astronomical telescopes are mounted on two perpendicular axes in order to give access to any point in the sky. Telescopes are driven by electric motors to compensate for Earth rotation, so that the telescope continues to point toward a particular celestial object. Most telescopes use the equatorial system of mounting, in which one axis is parallel to the Earth's polar axis and the other axis is used for adjustments in declination. The development of computer-controlled drive along both axes, however, has made altazimuth mountings—mountings on vertical and horizontal axes—desirable, because they are simpler and more economical. Several large telescopes have such mountings, including the Multiple Mirror Telescope (MMT) on Mount Hopkins, Ariz., which operates in the visible and near-ultraviolet spectral regions and performs as an interferometer in the infrared.

Design Innovations

The MMT represents one of several design innovations that have been adopted by telescope makers in the late 20th century to avoid the extreme technical problems of producing very large single mirrors and keeping them from sagging or being otherwise distorted by environmental effects. The MMT, which began operating in 1979, consists of six telescopes, each 72 in (1.8 m) in diameter, that are computer-guided to perform as a single light-gathering mirror 176 in (4.5 m) in diameter. The resolving power is limited to that of the individual mirrors, but when the MMT functions as an interferometer the resolving power is significantly increased. Other projects adopting the MMT approach include the proposed Columbus project to be constructed on Mount Graham, Ariz., by the mid-1990s and the planned Very Large Telescope (VLT) of the European Southern Observatory.

The mounting for the optics of the giant Keck Telescope on Hawaii's Mauna Kea sits inside the completed dome of the observatory. The innovative optics of the 390-in (9.9-m) telescope consist of 36 separate hexagonal segments that are designed to function as a single mirror.

Mirrors of a size larger than 200 in (5.1 m) still present major design problems, and one innovative approach to their construction is being used by an American astronomer, Roger Angel. His team, working at the University of Arizona, has developed a technique for spin-casting mirrors rather than starting with giant slabs of cooled glass. Molten borosilicate glass is placed in a mold that creates a lightweight honeycomb backing to the paraboloidal surface produced by spinning the mold. Another innovation is the "active optics" proposed for the VLT; hundreds of servomotor-driven mounting points will support the VLT's four thin mirrors and counterbalance any warping caused by temperature change or gravity.

Still another innovation is seen in the segmented-mirror design of the Keck Telescope on Mauna Kea, Hawaii, built by the California Institute of Technology and the University of California. The mirror, 390 in (9.9 m) wide, consists of 36 hexagonal mirrors each about 72 in (1.8 m) wide and weighing 635 kg (1,400 lb). The mirrors are placed under stress and then ground and polished to a spherical shape. When the stress is relieved, the mirrors assume their desired curvatures for the final, computer-controlled array.

Computerization is, in fact, assuming a leading role in many modern telescope functions. For example, the Advanced Technology Telescope at Australia's Mount Stromlo and Siding Spring Observatories has a fully computerized control system, and a photoelectric telescope at Fairborn Observatory in Arizona is programmed to function completely automatically for up to several years, if desired.

See also: OBSERVATORY, ASTRONOMICAL.

Telesio, Bernardino [tay-lay'-zee-oh] Bernardino Telesio, b. 1509, d. Oct. 1, 1588, was an Italian philosopher and scientist who reacted against 16th-century Aristotelianism. He taught at Naples and at Cosenza, where with others he formed an academy (today the Accademia Telesiana) dedicated to the pursuit of natural science.

In his writings Telesio portrays the universe as a closed, determinate system always operating in the same way. From sense data the individual can come to understand and to control the universe. All things arise through the interaction of three principles—heat, cold, and matter—which have been created by God, who exercises a general providence over the universe. Because all nature is governed by these principles, the difference between animate and inanimate existence is a question of degree. Animate beings possess a subtle, or rarified, spirit. Pleasure and pain are sensations produced by health and decay, and behavior accords with the instinct of self-preservation. Unlike other animals, human beings are endowed by God with a higher soul.

teletext Teletext is the generic name for electronic systems that transmit data via broadcast or cable TV signals to specially equipped television receivers. Teletext services generally provide about 100 "pages," or frames, of text and graphic information, usually timely material such as news headlines, sports scores, weather, and traffic or financial reports. Information is grouped by subject "menus," and viewers can request that frames be displayed on demand, usually by keying numbers into a hand-held, remote-control device. Entertainment information (such as TV program listings) and TV program captions (for hearing-impaired viewers or foreign-language subtitles) can also be transmitted via teletext.

Teletext systems use the "vertical blanking interval" (VBI) of the TV signal. The VBI is a thick black bar that may be seen when the video signal rolls on a TV screen; it carries 21 scanning lines, 8 of which have been allocated by the Federal Communications Commission (FCC) for teletext and data transmission. Teletext data is encoded within a standard TV signal, but users must have a special decoder to retrieve and view the text and graphic content. Such decoders may be built into a TV set or cable TV decoder, or may be installed as an external device.

television Television is the electronic transmission of moving images with accompanying sound, sent—usually in color—from a central source or sources to home television screens.

From the 1950s, when television viewing first became common in the United States, until the mid-1970s the technology available to the television audience was relatively simple and consisted essentially of a TV set. The 1980s, however, witnessed an explosion of new devices for home entertainment, all of them outgrowths of basic television technology. The entire field, including television itself, is now referred to as *video,* a word that includes in its meaning almost all the systems devoted to electronically creating images.

The article VIDEO introduces the field with a discussion of its history, the industries involved in producing video devices, and the effect of various branches of video on education, business, and communications. VIDEO TECHNOLOGY describes the basic science underlying video techniques and devices and outlines the various technologies involved. VIDEO ART, VIDEO GAMES, and VIDEO MUSIC are outgrowths of the technology that are both entertaining and offer practical and artistic possibilities. The PAINTBOX is a basic tool of the video artist.

VIDEOTEX and TELETEXT are methods of providing two-way interaction between the television viewer and the broadcaster or cable system. VIDEO CAMERA and VIDEO RECORDING describe the methods used to record images and sound electronically.

TELEVISION PRODUCTION describes how a TV program is made. TELEVISION TRANSMISSION outlines the various types of image transmission, including CABLE TV and COMMUNICATIONS SATELLITES. TELEVISION, NONCOMMERCIAL discusses the history and functions of educational and public television. RADIO AND TELEVISION BROADCASTING examines the development of each industry and their relationship to one another.

television, noncommercial Noncommercial television is a system of broadcasting that is financed by means other than advertising revenues. In noncommercial television, stations supply programs directly to the audience, whereas, it might be said, commercial television supplies audiences to advertisers.

The United States. As U.S. television broadcasting blossomed in the 1940s and '50s, it followed the patterns of radio broadcasting with regard to financing as well as to regulation (see RADIO AND TELEVISION BROADCASTING). Commercial television broadcasting came to derive its economic power from the existence of three networks whose coordination of broadcast schedules allows the airing of advertisements on a nationwide basis. The Communications Act of 1934 (a slightly modified reenactment of a 1927 law and the basis for all U.S. radio and television broadcasting regulations) was based on the notion that U.S. broadcasting was a local responsibility exercised by individual station licensees. The same year saw the defeat of the Wagner-Hatfield bill, which would have allocated 25 percent of U.S. broadcasting frequencies for educational purposes. Although schools and colleges had been among the most active of radio broadcasting's pioneers (72 educational stations were on the air by 1923), the absence of a protected portion of the spectrum for these stations caused a decline throughout the 1930s and '40s. Commercial broadcasters aired a certain amount of nonprofit, "sustaining" programming; how much (and how good) depended mostly on their public-relations needs, which fluctuated widely.

Noncommercial television broadcasting languished until 1952, when Frieda Hennock, a member of the Federal Communications Commission appointed by President Harry S. Truman, spearheaded a drive to reserve as-yet-unlicensed television channels for education. Set aside were 242 channels, but most of them were in the hard-to-tune ultra-high-frequency (UHF) band—and no funds were allocated to pay for programs or administration. Nonetheless, a loosely knit chain of educational television stations emerged in the 1950s and early 1960s, funded at first by the Ford Foundation and after 1962 by grants from the federal government.

In 1967, Congress passed the Public Broadcasting Act, and noncommercial television and radio in the United States had a national mandate for the first time. Great care was taken, however, that Public Broadcasting not become a "fourth network." Authority to run the system was divided between competing local stations (303 by 1984) and two overlapping Washington bureaucracies: the Public Broadcasting Service (PBS) and the Corporation for Public Broadcasting (CPB). Chronically underfunded, PBS is financed principally from viewer donations, private sponsoring underwriters, and congressional appropriations (which have been markedly reduced). Thus hampered, public television has evolved into a generally noncontroversial and noncompetitive supplement to the commercial networks.

The strongest area of public broadcasting's schedule is in cultural programming—science documentaries, concerts, operas, plays (especially historical costume dramas), and children's programs. Many of the best children's programs—including, notably, SESAME STREET—have been products of the Children's Television Workshop, an independent, nonprofit organization.

Other Countries. Probably the best-known noncommercial television system is the British Broadcasting Corporation (BBC), created by royal charter in 1927. The BBC was established to "educate and enlighten," a philosophy diametrically opposed to the U.S. system, in which commercial broadcasters attempt to anticipate and fulfill viewer preferences. The BBC, and many similar broadcasting organizations in Western Europe and Japan, are funded on an entirely different basis from U.S. public television. An annual license fee on every television set in the country ensures not only adequate operating revenues, but also financial stability, political insulation, and room for long-range planning. Since 1954, Britain has had a "mixed" broadcasting system, with the profit-oriented Independent Broadcasting Authority now running two of Britain's four television channels.

Canada also has a dual system. The Canadian Broadcasting Corporation (CBC), a public body created in 1936, is financed by the government, with supplementary advertising revenue. Canada's commercial network is CTV. In recent years various Western countries have tried to retain BBC-like quality while increasing decentralization as well as access by a wide range of constituents. The best-financed (and perhaps technically most advanced) noncommercial broadcasting system is the Japanese NHK, which exists side-by-side with commercial stations. The most stringently controlled systems are those in authoritarian developing countries, where television and radio are frequently used for personal propaganda by chiefs of state.

television production

television production A television production is the creation of a television show. In a broader sense, TV production also involves pre- and postproduction activities such as scriptwriting, set design, and videotape editing.

Television production is loosely divided into broadcast and nonbroadcast. Broadcast television is generally produced by the commercial TV stations and professional production companies that make the dramas, comedy series, newscasts, documentaries, game shows, and advertisements familiar to television viewers. Nonbroadcast television is produced for a much narrower audience. Businesses, private production companies, and some college TV studios specialize in creating educational and industrial programming used in schools or for on-the-job training. Much of today's TV production is performed on a small scale in hospitals, churches, and schools for demonstration or training purposes, for recording speeches, or for documenting events. Some of these shows may appear on the public channels made available to communities by their cable-system operators.

The Production Staff. In small educational, cable, and industrial TV studios, all phases of a TV production might be handled by one or two people. In larger commercial studios and broadcast TV stations, teleproduction activities are assigned to a number of specialists. They include the executive producer, who manages budget and coordinates advertising and other financial support. He or she is often in charge of several programs or series. The produc-

The central device in a television control booth is the switcher, which cuts between two or more video sources (camera and videotape, for example), adding effects and superimposing titles and other graphics.

Both the newscaster and the cameramen in the studio at Cable News Network wear headphones to hear directions from the control booth. The newscaster's is a tiny speaker lodged in one ear.

er hires personnel for an individual production and coordinates production elements. The director directs talent during production, selects shots, and coordinates the production crew, transforming the script into the final TV production. TV writers range from those who create dramas and other staged fiction to the staff people who write news reports and other verbal material. A TV script usually includes rough visual and sound directions. "Talent" includes actors, reporters, hosts, guests, off-camera narrators—anyone who appears before the camera, or whose voice is heard.

The camera operator aims and moves the camera and composes shots. The audio engineer mixes sound from the studio microphones with recorded music and sound effects to produce the final sound that will be broadcast or recorded. The technical director operates the camera switcher, switching from camera to camera upon command from the director. The lighting director aims and balances the brightness of the studio lights. The video engineer adjusts electronic camera controls for optimal TV picture, and may also operate the videotape recorders. The floor manager supervises studio activities, relays the director's cues to the talent, handles cue cards, and coordinates the work of the stagehands who set up and move sets, props, and equipment.

Finally, the editor takes the original tapes, which contain both video and audio tracks, and melds all the segments together using editing videocassette recorders and other electronic instruments.

Video Equipment Systems. In a TV studio the cameras send their pictures (video) into the control room, where the signals are passed to a switcher/special effects generator and to a bank of control-room monitors. The director chooses the desired shot from these camera monitors and calls it out to the technical director. The technical director then pushes the corresponding button on the switcher, selecting that particular shot to be recorded or broadcast. Switching instantly from one picture to another is called a cut. Other controls on the switcher permit pictures to be mixed together in various ways, resembling the basic effects used in movie editing: fade in, fade out, dissolve, split screen. In the wipe, a border moves across the screen, replacing one picture with another. In the key, text, graphics, or parts of another scene appear to be laid over the original TV image. For the chroma key, a performer or prop is shown before a blue background, which is then electronically removed from the picture and replaced with another camera's picture—a weather map, for example.

The more elaborate digital video effects whereby a picture can be bent, rotated, wrapped into a cylinder, or molded into a ball require digital frame store devices, which divide the picture into thousands of picture elements (pixels) and convert these elements into numbers. These numbers are algebraically manipulated by computer and then converted back into a modified picture. For instance, doubling all the horizontal pixels would create a picture stretched to twice its normal width.

Electronically generated titles and graphics, video from another videotape, or a signal received from a satellite or from a portable microwave transmitter several miles away may provide other visual elements that can be mixed with the camera shots. Photographic slides and films can also be mixed, once they have been translated into video images in a machine called a telecine.

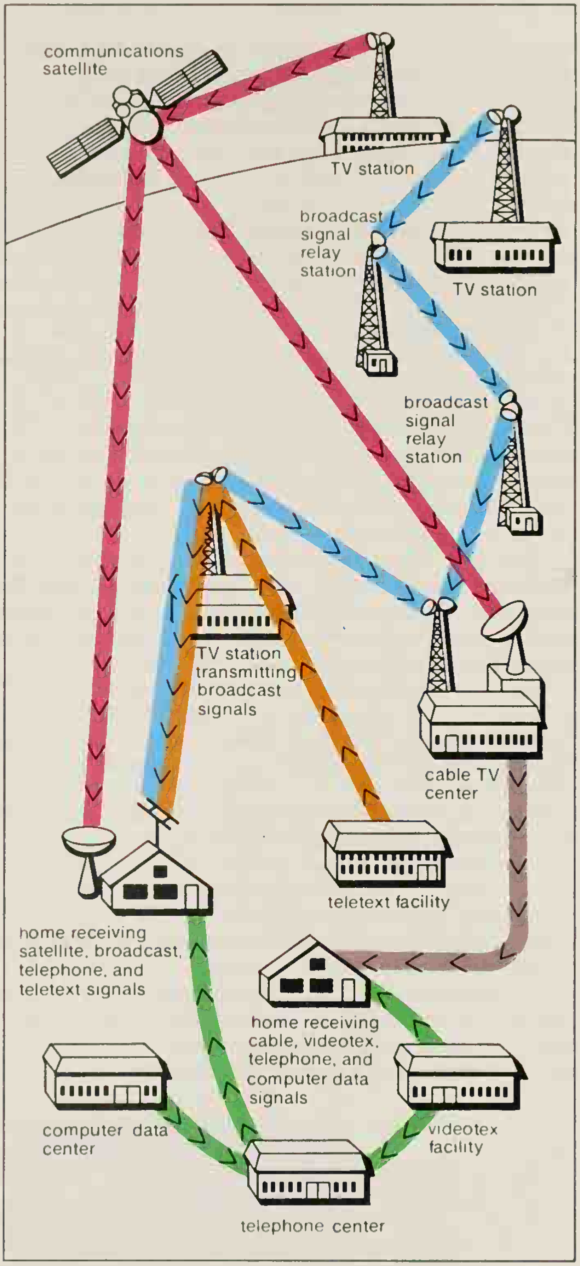
Sound (audio) is picked up by microphones in the studio and is routed to an audio mixing console, where the sound engineer and the director select which microphones are to be heard and their sound levels. Recorded music, sound effects, or the sound from other videotapes or movies can also be mixed with the microphone sound. The final audio and video signals are then recorded on a videotape recorder or are sent to a transmission facility to be broadcast "live."

TV cameras must have their electronic signals synchronized with one another, in order for their pictures to be mixable by the switcher. This task is performed by a master sync generator. The sync generator may also be used to create test signals like color bars, which are used by the video engineer to calibrate and adjust the color video signals in the system.

The most important video test equipment are the waveform monitor and the vectorscope. The waveform monitor graphically displays the video signal's intensity. The strengths of the various components of this signal are compared and matched to a standard marked on the waveform monitor's screen. The vectorscope measures the phase of color video test signals, and displays this information as dots on the vectorscope screen. When the color is adjusted correctly, the dots fall exactly within little boxes etched on its screen.

Portable TV systems may have only one camera connected to one videotape recorder; or they may have several cameras controlled from a miniature control room in a van or trailer. The camera signals can be monitored for quality, switched or mixed, and recorded; or they can be transmitted via microwave back to the main studio to be combined with other elements of the TV show.

In postproduction, videotape is edited, and special effects, titles or graphics, and sound effects may be added.


communications satellite
TV station
broadcast signal relay station
TV station
broadcast signal relay station
TV station transmitting broadcast signals
cable TV center
teletext facility
home receiving satellite, broadcast, telephone, and teletext signals
home receiving cable, videotex, telephone, and computer data signals
computer data center
videotex facility
telephone center

In this schematic view of the different modes of television transmission, the blue represents the most basic and the oldest system: broadcast transmission, where a TV station sends its signal out from a tower, and it is picked up and retransmitted in areas—such as valleys—where the signal often fades. The red lines are communications satellite signals, which are received by the satellite from TV networks, cable, TV production, and other companies, and are returned to "earth stations," large, commercially operated dish antennas. To prevent unpaid use of satellite signals by home dish owners, many signals are now scrambled, and all dish owners must use decoders in order to receive them. Brown is the cable wire, which carries satellite and broadcast signals to home subscribers. The green represents videotex and computer transmissions via telephone, as well as ordinary telephone signals. The orange is the teletext signal—actually part of the TV signal, but receivable only by those with special teletext decoders.

Most complex TV productions are assembled in postproduction because it is nearly impossible to coordinate live the many shots, decisions, and details that go into such productions.

television transmission Television images can be relayed from one point to another by a variety of transmission systems, which include the following: (1) Over-the-air propagation of ELECTROMAGNETIC RADIATION, or waves, such as those used for ordinary TV broadcasting. These are normally radiated in an omnidirectional pattern, and over 85 million TV households in the United States receive such transmissions. (2) The use of dedicated lines (cables laid underground or strung on existing power or telephone poles) with either metallic or fiber-optic cores that carry the signals and connect the program source (the head end) with the subscriber. (3) Geosynchronous or orbiting satellites receiving TV signals from a ground station (uplink) and relaying them back to Earth over an antenna that covers a specified terrestrial area. These signals are then picked up by receiving dishes.

The Television Channel. Television signals are transmitted over internationally allocated blocks of frequencies referred to as channels (see FREQUENCY ALLOCATION). These channels are situated in various noncontiguous frequency ranges of the electromagnetic spectrum (see RADIO). These ranges are: (1) Very High Frequency (VHF): 54–72 MHz (channels 2–4), 76–88 MHz (channels 5–6), and 174–216 MHz (channels 7–13); (2) Ultra High Frequency (UHF): 470–806 MHz (channels 14–69); and (3) Super High Frequency (SHF): 0.9–40 GHz for terrestrial and satellite services. Television transmission systems around the world are not uniform. Consequently, there is no compatibility between television broadcasts in North America and Europe.

Television image scanning consists of horizontal lines that are sequentially displaced in a vertical direction until the whole image area is covered (see VIDEO TECHNOLOGY). The scanning of a single image is called a field, and the horizontal and vertical scan rates are normally synchronous with the local power-line frequency. Because the world is generally divided into 50-Hz and 60-Hz electrical power frequencies, television systems use either 50-field or 60-field image-scanning rates.

The television broadcasting standards now in use include 525 lines, 60 fields in North America, Japan, and a few other countries, and 625 lines, 50 fields in Europe, Australia, most of Asia, Africa, and a few South American countries.

RF (Radio Frequency) spectra and channel allocations also vary outside of North America. VHF frequencies extend from 45.0 MHz to 229.75 MHz, and UHF from 471.25 MHz to 860.75 MHz. The normal North American channel bandwidth (the width of frequencies required to carry the channel) is 6.0 MHz.

The assignment of television channels in the electromagnetic frequency spectrum is not only for normal home television services, but also for a variety of broadcast-related services that transmit images and sound between various points. VHF and UHF are purely home-viewer-oriented frequency bands, but the SHF bands cater to the multiple distribution services (MDS) of pay-per-view TV systems in the 2.15-GHz range.

Terrestrial Broadcast Systems. These systems include both omnidirectional broadcasting and point-to-point broadcasting using line-of-sight propagation. The omnidirectional systems can include both high- and low-power TV stations that radiate their programs over a given service area using an antenna placed at the highest altitude possible overlooking that area. Local topography, including hills, valleys, or high-rise buildings, will interfere with the reception of the TV signals if they are adjacent to, or between, the transmitting antenna and the home receiver. The interference will appear as a multipath signal or "ghost" displaced to the right of the principal image, caused by reflections from these nearby surfaces.

Television signals radiate in straight lines, and in hilly terrain the signal shadows in the valleys prohibit good TV reception. To overcome this, TV stations have low-power satellite repeaters that pick up the original signal at a point above the valley, then retransmit it into the shadow area.

Low-power television (LPTV) is also used for limited coverage of a primary service area by broadcasters catering to a particular group of viewers with some specific commonality, such as religion, ethnic background, or business interests.

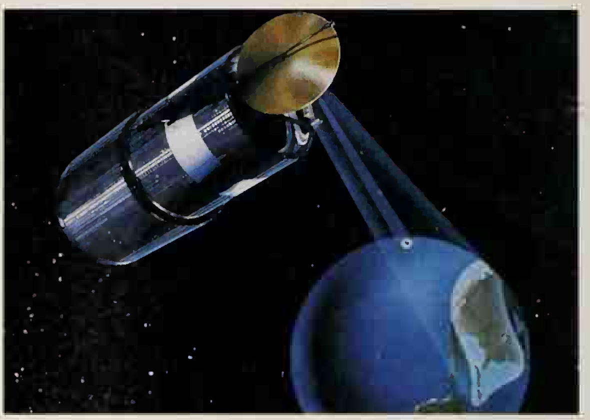
Point-to-point broadcast systems usually use SHF links to provide transmission of TV images from the studio to the transmitter, or from a news event to the studio. These transmissions are made over parabolic (dish) antennas ranging in diameter from 0.3 to 1.8 m (1 to 6 ft) and are set up to "look" at each other over the distance to be covered.

Omnidirectional TV broadcast systems are limited in radiating their signals to the geographic horizon, and these signals decay in strength as the square of the distance. Therefore home viewers in the primary signal area, or within a 48-km (30-mi) radius, get an acceptable picture, but beyond that radius, "fringe area" reception will be marginal.

Nonbroadcast Systems. There are two additional methods of bringing television signals to the home: cable television and satellite transmission. CABLE TV first developed to serve shadow areas, by putting up a community antenna and distributing the signals by coaxial cable to the homes in the valley.

Eventually it became obvious that picking up a variety of clear channel signals and redistributing them, to viewers willing to pay both for better picture quality and for a greater range of programming, was a viable business. Cable companies today pick up local and distant channels at "Earth stations" by using large, high-quality receiving dishes to bring in special programming. All of these channels are processed at the cable-TV facility (head end) and are then redistributed to subscribers.

Cable television is most easily installed in areas where there are no problems with stringing or trenching wires, and where population density can support the capital outlay needed to implement a system.



A solar-powered satellite maintains its geosynchronous orbit over the Earth's equator. Its main dish antenna casts a "footprint"—the area where its signals are received—over the continental United States, while a spot antenna covers Hawaii.

COMMUNICATIONS SATELLITES for television use are launched by private companies, as well as by Intelsat (International Telecommunications Satellite Consortium). The U.S. satellites beam TV signals to Earth from geostationary equatorial orbits, 35,900 km (22,300 mi) above Earth's surface. They are positioned between 75° and 145° west latitudes, to cover the North American continent. Their transmitting antennas are positioned to create a "footprint"—a particular area on the continent that is covered by their signal. Each satellite has many transponders, devices that receive signals from Earth, amplify, change signal frequency, and retransmit them. Each transponder can transmit one color-TV channel, or relay a large number of audio or data signals in channels within its frequency spectrum. Transponder capacity, as well as the number of transponders per satellite, may increase in the future.

Satellite transmissions are used to efficiently distribute TV and radio programs from one geographic location to another by networks, cable companies, individual broadcasters, program providers, and industrial, educational, and other organizations. Programs intended for specific subscribers are scrambled so that only the intended recipients, with appropriate decoders, can receive the program.

Direct broadcast satellites (DBS) are another means of giving viewers access to TV programming, although at this time operational plans exist only in Europe and Japan. When they come, DBS systems in North America will operate in the KU band (12.0–19.0 GHz). Their signals will be picked up by home satellite receivers, small-dish TVROs (for television receive only) that are aimed at the specific satellite carrying the desired programs. DBS home systems consist of the receiving dish antenna and a low-noise amplifier that boosts the antenna signal level and feeds it to a coaxial cable. The cable converts the

SHF signals to lower frequencies and puts them on channels that the home TV set can display.

DBS satellites must have the capacity to beam very powerful signals back to the small dishes (some may be only 0.3 m/1 ft in diameter) that will be used by homeowners, and they will therefore cost almost twice as much as ordinary satellites. Japan has already launched an experimental DBS satellite for home use, and France is planning to launch two.

Ancillary TV Services. The television channel may be used in part, or totally, to provide ancillary information to the viewer that is not primarily intended for home entertainment. These services may be program related, such as closed captioning for the hearing impaired, or nonprogram related, such as teletext or videotex. Another potential is high-definition television (HDTV), which would be transmitted in a nonstandard method.

Closed captioning uses a blank line in the vertical interval of the TV signal to transmit digital data carrying subtitles for the program material. A special decoder in the home TV receiver converts this data into captions on the TV screen.

TELETEXT uses a number of blank lines in the vertical interval to provide high-speed digital data containing "pages" of information that the viewer can select and display by using a numeric keypad that controls a special teletext decoder.

VIDEOTEX transmissions use high-speed data signals in a full TV channel that is designated solely as an information source. It provides viewers with a wide variety of high-density information from data bands that have access to stock-market quotations, news wires, airline, train, or bus schedules, product catalogs, and encyclopedia articles.

High-definition television uses more lines and a much wider bandwidth to generate images of substantially higher quality than normal television. Because of this, special-broadcast transmission systems and HDTV receivers are needed.

telex see TELEGRAPH

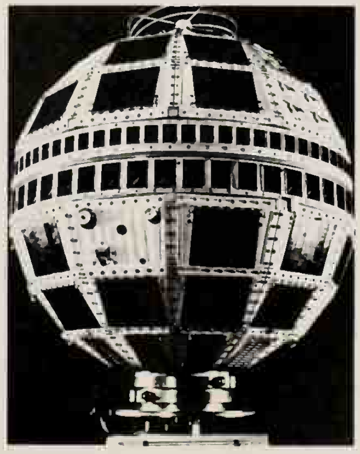
Tell, William William Tell is a legendary hero of Switzerland and a universal symbol of resistance to oppression. He was supposedly a native of Bürglen in the area of Uri, which was under the tyrannical control of the bailiffs of Austrian overlords. In 1307, Tell is supposed to have disobeyed the commands of Bailiff Gessler. He was then forced to shoot an apple placed on the head of his son; he succeeded and went on to lead a victorious uprising. The German dramatist J. C. Friedrich von SCHILLER wrote *William Tell* (1804), a play that Gioacchino ROSSINI made into an opera.

Teller, Edward Edward Teller, b. Jan. 15, 1908, is a Hungarian-born American physicist known for his work on the hydrogen bomb. During World War II he was a member of the MANHATTAN PROJECT for the development of the atomic bomb. At that time he also began formulating the theoretical foundations for a hydrogen fusion bomb and was a major proponent of its development. He received (1962) the Atomic Energy Commission's Fermi Award and has received other honors and awards for his contributions to chemical and nuclear physics.

Teller, Henry Moore Henry Moore Teller, b. Allegany County, N.Y., May 23, 1830, d. Feb. 23, 1914, a U.S. senator (1876–82, 1885–1909) from Colorado, was known mainly for the Teller Resolution (1898); attached to the declaration of war against Spain, it committed the United States to an independent Cuba. Teller was also secretary of the interior (1882–85). He broke with the Republicans in 1896 over the free-silver issue and became a founder of the Silver Republican party. In 1900 he became a Democrat. Despite his sponsorship of the Teller Resolution, he voted against a similar independence pledge for the Philippines.

tellurium [tel-ur'-ee-uhm] The chemical element tellurium, located in Group VIA of the PERIODIC TABLE, is a grayish white, brittle, lustrous solid. Its symbol is Te, its atomic number is 52, and its atomic weight is 127.6. Although it exhibits some metallic characteristics, tellurium is classed as a nonmetal. Its chemical properties resemble those of selenium. Tellurium was first extracted by F. J. M. von Reichenstein in 1782. M. H. Klaproth suggested (1798) that the new element be named for the Latin word for "earth," *tellus.* Tellurium is used to increase ductility in steel and copper alloys and to color glass and ceramics.

Telstar Telstar was the first commercial experiment in the use of active-repeater communications satellites in low, elliptical orbits. *Telstar 1* was launched by a Delta rocket from Cape Canaveral on July 10, 1962. It went into an orbit with an apogee of 5,636 km (3,503 mi) and a perigee of 954 km (593 mi) and with a period of 158



The telecommunications satellite Telstar *2 relayed transmissions between the United States and Europe from 1963 to 1965. It measured 87 cm (34.5 in) in diameter and weighed 79 kg (175 lb). Solar cells, arranged in rectangular panels, kept its batteries charged while in orbit. The tiny rods around its circumference are microwave antennas.*

min. *Telstar 2* was similarly launched on May 7, 1963, into a more eccentric orbit with a period of 225 min.

The satellites were multifaceted aluminum spheroids manufactured by the Bell Telephone Laboratories for the American Telephone and Telegraph Company, which paid NASA to launch them. Unlike later communications satellites, *Telstar 1* had only a single transponder to receive and retransmit signals. The satellite transmitted the first direct television pictures from the United States to Europe on July 10, 1962. *Telstar 1* ceased operation on Feb. 21, 1963. Like the earlier satellite, *Telstar 2* could process either six simultaneous two-way telephone calls or a single television channel. On its tenth orbit, *Telstar 2* transmitted the first transatlantic color-television program. It continued to operate satisfactorily until it was shut off in May 1965.

See also:.COMMUNICATIONS SATELLITE.

tempera [tem'-pur-uh] Tempera is a painting technique in which water-soluble paints are mixed with (or "tempered" by) an emulsifying agent with binding and adhesive properties. The emulsifier may be a synthetic agent or a natural substance such as animal glue, milk, fig sap, or egg yolk (historically the most commonly used substance). Tempera can be applied to paper, canvas, primed wood, or plaster surfaces. When used on dried plaster it is known as *fresco secco* (see FRESCO PAINTING). One of the oldest painting techniques, tempera was widely used by the Egyptians, Greeks, and Romans. The Byzantines were among the first to use an egg binder.

Tempera dries quickly, becoming insoluble in water so that several layers of paint can be applied. The resulting overlay of semiopaque paints gives tempera paintings a luminous quality, but such a gradual buildup requires patient, methodical work and discourages spontaneous inventiveness and fluid forms. The image must be well worked out in advance using some sort of preparatory drawings—a necessity that dictates a painstaking and crisply linear style. Tempera, however, offers a wider color range and allows for the inclusion of many finer details than true fresco, or *buon fresco*. Tempera was ideally suited to the cooperative workshop practices by which paintings were produced from early Christian times through the 15th century.

After having been almost entirely supplanted by oil painting during the early 16th century, tempera was not revived until postimpressionist artists rediscovered its unique properties.

temperance movement The temperance movement in the United States during the 19th and 20th centuries was largely a nonurban, Protestant-led drive to promote, by both persuasion and law, abstinence from alcoholic beverages. Although moderate drinking was generally accepted during the 18th century, by the early 19th century, many observers began to perceive an increase in the use—and abuse—of drink. With the immigration of ethnic groups whose culture accepted the use of these beverages, the growth of cities, and the concentration of industrial workers in them, reformers became increasingly aware of and concerned about excesses in the consumption of alcohol. The American Temperance Society, founded in 1826, began gathering pledges of abstinence. In the 1840s the Washington Temperance Societies conducted revival-style meetings to encourage similar pledges. Reformer Neal Dow persuaded Maine to approve (1846) the first statewide prohibition law and then led attempts to secure such laws elsewhere; the Civil War interrupted this effort. The Prohibition party, formed in 1869, ran presidential candidates, including Dow. The Woman's Christian Temperance Union (see WCTU), in 1874, and the politically potent Anti-Saloon League, established on a national scale in 1895, also favored banning the liquor traffic. Despite this intense activity and the passage of many liquor laws, the sale and use of alcohol remained widespread. Then during World War I the temperance movement was unexpectedly aided by the need to conserve grain. In 1917, Congress passed the 18th Amendment (see PROHIBITION), ratified in January 1919; however, it proved unenforceable and was repealed by the 21st Amendment, ratified in 1933. Thereafter, the temperance movement waned. With the founding of Alcoholics Anonymous in 1935, attention began to shift to the treatment of ALCOHOLISM.

temperate climate The term *temperate* is used to refer to any climate that has moderate temperatures or to all climates of the middle latitudes. It implies an absence of great seasonal extremes of temperature in regions that are also neither continuously hot nor continuously cold throughout the year.

Air masses and storms traveling in the mid-latitude westerly wind belts of each hemisphere combine with land and water effects to create a wide variety of climates within the temperate zones. Storms are especially frequent in winter. In the Northern Hemisphere the west coasts of continents have a temperate maritime climate. In contrast, the continental interiors have greater annual ranges of mean and extreme temperatures. Broad expanses of water in the Southern Hemisphere also limit the annual temperature range.

temperature Temperature is a measure of the escaping tendency of heat and an index of an object's thermal condition. Heat always flows of itself from high to lower temperatures. Two objects are in mutual thermal equilibrium, regardless of shape, color, chemical composition, or any other property, only if they have the same temperature.

Temperature is related to molecular motion. The greater the variety and disorder in the random motions of an object's molecules, the higher its temperature. At ABSOLUTE ZERO, random motions vanish.

Temperature may be measured by any property that depends on a substance's thermal state: volume (at constant pressure), electrical resistance, and even visible color for extremely hot objects such as stars. The THERMOMETER works on the principle that most substances expand when heated. When confined in a glass tube, for example, a column of mercury will increase in length as it gets hotter. Different substances expand at different rates, but the two most commonly used temperature scales are set up so that the difference between the boiling and freezing points of water is 100 degrees (0 to 100 on the Celsius scale) or 180 degrees (32 to 212 on the Fahrenheit scale). The Kelvin (K) scale has degrees the same size as the Celsius degree, and the Rankine scale has degrees the same size as the Fahrenheit degree. On the Celsius scale, absolute zero lies 273.15 degrees below the freezing point of water: that is, at –273.15. On the Fahrenheit scale, absolute zero lies 491.67 degrees below the freezing point of water: that is, at –459.67.

Absolute zero has been closely approached but can never be attained. Between, for example, 0.000001 and 1 K, changes in some physical properties are as pronounced as between 1 and 1,000,000 K for other properties.

See also: HEAT AND HEAT TRANSFER; THERMODYNAMICS.

temperature, body see BODY TEMPERATURE

temperature inversion see INVERSION

tempering Tempering is the process of toughening glass and metals, particularly steel. During its manufacture, steel is heated to a high temperature and quenched or cooled quickly. This rapid cooling creates a buildup of internal stresses that cause the metal to become brittle. The tempering of steel involves the subsequent reheating of the metal to a temperature below the point to which it was first heated. It is then allowed to cool slowly. This reheating and cooling process softens the steel, relieving the internal stresses set up by the original heating and quenching operations. The softening is accompanied by a large increase in toughness. Steel is generally tempered at temperatures ranging from 200° to 600° C (400° to 1,100° F).

Tempering glass involves first heating it until it becomes pliable and then cooling it by air blasts or by immersion into liquids. Tempering can increase the hardness of glass up to five times its normal hardness.

See also: ANNEALING.

Tempest, The Probably the last play that William SHAKESPEARE wrote before he retired from the theater, *The Tempest* (*c.*1610–11) is a romantic comedy emphasizing magical and wonderful effects. Thus Miranda, who has never seen a human being other than her father, Prospero, is moved when she first sees other men: "How beauteous mankind is! O brave new world/That has such people in't!" Shakespeare endows the wooing of Ferdinand and Miranda with an earnestness that is never undercut. Caliban, also a natural creature but a born monster, evil, deformed, and ineducable, stands in sharp contrast to Miranda. The play has no direct literary source but is related to Renaissance travel literature and especially to some contemporary pamphlets about Bermuda.

Templars [temp'-lurz] The Poor Fellow-Soldiers of Christ and the Temple of Solomon, or Knights Templar, were a military and religious order founded in Jerusalem during the CRUSADES. The founders were Hugh de Payns and Geoffroy de Saint-Omer, knights who established (1118) a religious community to protect pilgrims in the Holy Land. Baldwin II, Latin king of Jerusalem, gave them a dwelling on the ancient site of the Temple. Saint BERNARD OF CLAIRVAUX drew up the order's rules, which included the notion of fighting the enemies of God under vows of poverty, chastity, and obedience. The Templars, divided into knights, chaplains, sergeants, and craftsmen, were organized under a grand master and general council and were responsible only to the pope and not to secular rulers. Wearing a white cloak with a red cross, they attracted many nobles and soon became an expert military force and a powerful, wealthy order. After 1291, when the crusading forces were driven from Palestine, the Templars' main activity became banking—the lending of money (even to kings)—and their enormous landholdings and financial strength aroused great hostility among rulers and clergy alike.

PHILIP IV of France, sorely in need of money, charged the Templars with heresy and immorality (1307). They were arrested and put on trial, and confessions were extracted by torture. Similar attacks were mounted against the order in Spain and England, and Pope Clement V, after initially opposing the trials, suppressed the Knights Templar by papal bull at the Council of Vienne in 1312. When the Grand Master, Jacques de Molay, and other leaders of the Templars retracted their forced confessions and declared their innocence and the innocence of the order, Philip had them burned at the stake at Paris on Mar. 18, 1314.

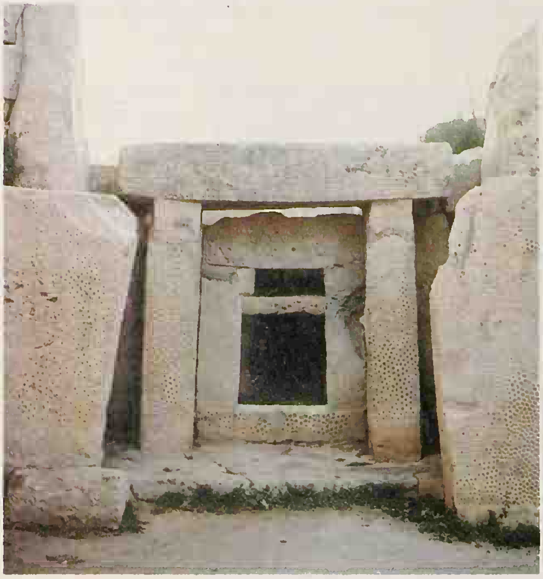
An illustration (c.1470–83) from Boccaccio's Lives of Illustrious Men *portrays Philip IV of France attending the execution (1314) of Jacques de Molay, grand master of the Knights Templar. Philip's persecution of the Knights led to the suppression of the order.*

temple A temple is a building or enclosed space set aside for worship. Temple architecture in general can be divided into three categories: the open-air sanctuary; the cave, or rock-cut, temple (a secret place of worship); and the house for the deity or cult object, also called the freestanding temple. Not considered temples are the Christian CHURCH, the Jewish SYNAGOGUE, and the Muslim MOSQUE, although their forms and functions often resemble those of temples.

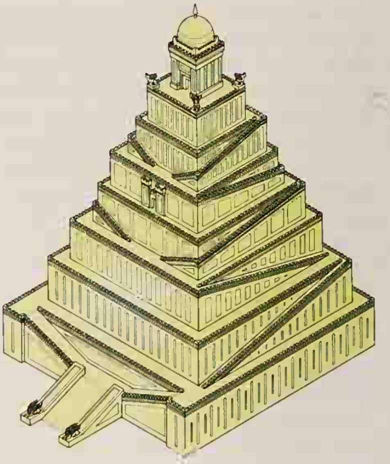
Prehistoric Temples. The oldest (*c*.6000–5650 BC) artificial temples extant are those discovered at ÇATAL HÜYÜK, Turkey. Constructed of mud-brick on a timber framework, these cavelike enclosures have plastered walls covered with paintings and molded sculpture dedicated to a MOTHER GODDESS cult. Other types of Neolithic temples include the open-air sanctuary of STONEHENGE (*c*.2100–1900 BC), which probably served a calendrical function, and the rock-cut, domed temples of Malta (*c*.3000–2000 BC), dedicated to a mother goddess cult.

Mesopotamia. The Mesopotamian temples of the period 3000–500 BC were intended to serve as houses for deities. Almost invariably rectangular in layout and built of mud-brick, they were the first raised structures of their kind—for example, the so-called White Temple at URUK (*c*.3000 BC), dedicated to the god ANU, was elevated by a 12.2-m-high (40-ft) artificial mound and approached by a ramp. True ZIGGURATS—stepped, pyramidal structures rising from a rectangular or square base—were built first by the Sumerian civilization. In the ziggurat at UR (*c*.2100 BC) the temple is placed atop a series of concentric mud-brick terraces piled one on top of the other to a height of more than 30.5 m (100 ft). The KASSITES reoriented their temples to face east and added sculpture in molded bricks.

Mnajdra, a megalithic temple on the southern coast of Malta, dates from the early Copper Age (c.2800 BC). This rock-cut temple is typical of the prehistoric Maltese sanctuaries, around which a religious cult associated with the mother goddess flourished.



This drawing depicts Etemenaki, a ziggurat dedicated to the god Marduk, built during the reign of the Neo-Babylonian king Nebuchadnezzar II (6th century BC). The ziggurat, a temple tower form that originated with the Sumerians, was renowned in the ancient world as the Tower of Babel.

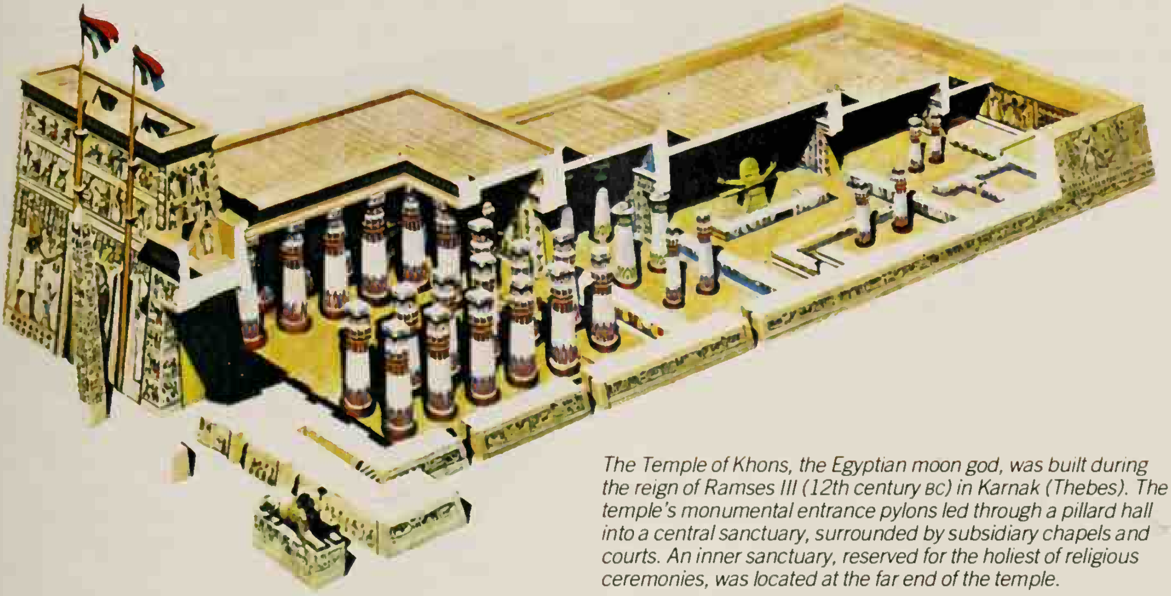


The earliest Assyrian temples, such as that of Ishtar (1241–1205 BC), had an off-axis doorway to the cult room and two flights of interior stairs leading to a niche for the cult statue. These internalized ziggurats gave way in late Assyrian architecture to true ziggurats that contained as many as seven different levels connected by a continuous ramp. NEBUCHADNEZZAR II's ziggurat (*c*.612–539 BC) at BABYLON had white, black, red, blue, orange, silver, and gold levels. The sacred rooms atop later ziggurats were used for astronomical observation as well as for devotional rites.

Egypt. Temples in ancient Egypt were of two main types: freestanding temples for deities and temples attached to funerary structures. Rock-cut temples of both types also were used. The purpose of freestanding temples was to house a cult statue, whereas the funerary shrines were built to receive the offerings for the dead.

Freestanding temples of the Old Kingdom period (2680–2258 BC) generally followed the layout of the Temple of Khentiamentiw (*c*.3000 BC) at ABYDOS, which is about 15.25 m (50 ft) long, trapezoidal in shape, and composed of successive rooms that culminate in a niche for the cult statue. Funerary temples such as that of Khafre (*c*.2600 BC) at GIZA, which were attached to PYRAMIDS by causeways, housed statues of the king, in which his spirit was thought to be present to receive offerings.

The greatest proliferation of Egyptian temple building took place during the New Kingdom period (1570–1080 BC). Three typical examples of freestanding temples are the Temple of Amon at KARNAK, the Temple of Amon at LUXOR, and the Temple of the Aten at Karnak, all of which were constructed between 2060 and 1200 BC. Basically similar in organization, all three temples had monumental gateways, or pylons, leading to a succession of courtyards and halls laid out along a central axis. As the worshiper moved along the axis, the interior gradually grew dim until almost total darkness shrouded the cult statue standing at the end of the axis. The vast rock-cut mortuary temple (*c*.1480 BC)



The Temple of Khons, the Egyptian moon god, was built during the reign of Ramses III (12th century BC*) in Karnak (Thebes). The temple's monumental entrance pylons led through a pillard hall into a central sanctuary, surrounded by subsidiary chapels and courts. An inner sanctuary, reserved for the holiest of religious ceremonies, was located at the far end of the temple.*

of Queen HATSHEPSUT at Deir el-Bahri is perhaps the outstanding structure surviving from the New Kingdom.

Mediterranean Periphery. Common features of HITTITE structures are central courtyards open to the sky, entrances on the axes, pillared halls on at least one side, and subsidiary rooms. The cult chamber usually is located off-axis and is lighted by outside windows. Typical examples (*c.*1400–1250 BC) can be found at Boğazköy, Turkey.

The most renowned temple of this age was the Temple of Solomon in Jerusalem. Completed (*c.*952 BC) with the aid of Phoenician artisans, it was destroyed in 586 BC; most of the knowledge about it comes from the Bible and from the evidence supplied by other Palestinian temples. Solomon's temple was built out of stone and had a flat wooden roof made from imported cypresses and cedar. Bronze pillars known as *Yakhin* and *Boaz*, which may have symbolized the relationship between the monarchy and the temple, stood in front of the edifice.

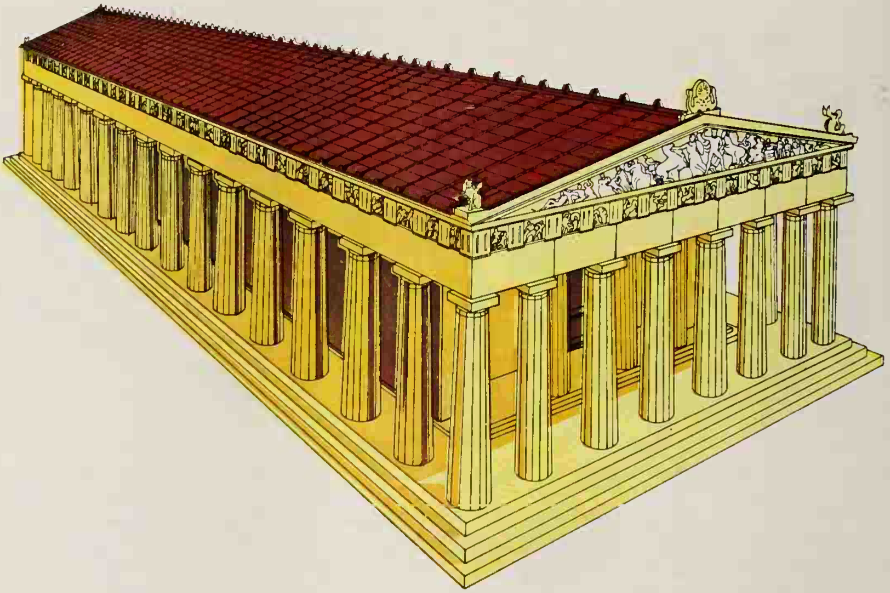
Minoan Crete and Mycenaean Greece. So far as is known, no monumental freestanding temples were built by the Minoan civilization of Crete (fl. 2200–1500 BC) except possibly Arkhanes. The west wings of Minoan palaces did contain shrines and associated rooms, and the palaces at KNOSSOS and Zakro (*c.*1600–1450 BC) had public altars situated in their central courts. The most significant feature of Mycenaean structures was their use of the megaron, or house form, which influenced much of early GREEK ARCHITECTURE.

Greek Temples. The earliest Greek temples date from the end of the Orientalizing period (7th century BC). Along with small funerary temples dedicated to heroes, buildings erected to house large cult statues were the principal form of temple at this time. The Mycenaean megaron plan seems to have provided the model for these early structures, which had two-columned porches and hipped or gabled roofs. The Temple of Apollo at Thermon (*c.*620 BC) in Aetolia was a true temple of the Doric order. Initially, the cult room, or cella, of Greek temples was a long, dark space with a row of columns down the center. Because this plan obscured the statue, the temple builders gradually adopted a shorter cella with two rows of columns, one on either side of the statue. At about the same time, the Ionic order began to appear.

The greatest Doric temples of classical Greece are the Temple of Zeus (designed *c.*460 BC) at Olympia and the Parthenon (447–432 BC) on the Athens ACROPOLIS. A century of refinement and experimentation produced in these buildings a harmonious blend of geometric proportions, optical effects, and sculptural decoration that have remained unmatched. Also reaching its apogee at this time was the Ionic order, whose delicate, graceful decorative effects were used to great advantage on the Acropolis in both the Erechtheum (421–405 BC) and the Temple of Athena Nike (*c.*427 BC).

In the temple architecture of the late classical period, which was inaugurated by Ictinus's Temple of Apollo (*c.*420 BC) at Bassae, more prolix decoration began to appear on temple exteriors. The newly designed Corinthian capitals made their initial appearance. Finally, a round temple form emerged for the first time in the Tholos (*c.*420 BC) at Delphi.

During the Hellenistic period the Ionic order prospered, the Corinthian order became more popular, and the Doric order declined. Among the huge Ionic temples that were erected during the 4th century BC in Anatolia, particularly striking are the Temple of Artemis (rebuilt 356 BC) at Ephesus, the Temple of Apollo (*c.*330 BC) at Didyma, and the Temple of Artemis (*c.*325 BC) at Sardis.



(Right) *The design of the Parthenon (*c.*447–432 BC) embodies technical perfection in classical Greek temple architecture. Dedicated to Athena and symbolizing the supremacy of Athens, the temple, built during the rule of Pericles, dominates the Athenian Acropolis.*

(Below) *The Pantheon (AD 118–28), a monument of imperial Rome, revived the use of brick and concrete in temple architecture. Its symmetry is enhanced by its hemispherical dome.*

All of these buildings are noteworthy for their complicated interiors.

Rome. Temples in republican Rome generally followed the Etruscan pattern of small structures that stood atop high podiums (see ROMAN ART AND ARCHITECTURE). They were made of a volcanic stone called tufa and featured a deep, columned porch and a narrow cella. An early example of this type is the Temple of Jupiter (*c.*510 BC) on the Capitoline. Toward the end of the republican era, temple building passed through a transitional phase. The Sanctuary of Fortuna Primigenia (*c.*80 BC) in Palestrina is an elaborate, symmetrically laid out, molded-concrete complex, in which the shrine itself seems lost amid the magnificent staircases, terraces, and fountains.

The victory (29 BC) of Emperor Augustus inaugurated an attempt to turn Rome from a city of brick into one of marble. Augustus chose to follow the Hellenistic and classical models of Greece, using concrete only in concealed parts of buildings. Many older temples were refaced with marble, and new shrines such as the Temple of Mars Ultor (2 BC) in the Forum Augusti were erected at the focal points of forum complexes.

The next great period in Imperial architecture was initiated by Emperor Hadrian, who built (AD *c.*118) the Temple of Trajan in Trajan's Forum and the domed PANTHEON (*c.*118–28) in Rome, which reintroduced molded concrete into temple architecture.

The Severans (r. 193–235) introduced colossal temples dedicated to exotic foreign deities. Especially notable was the Temple of SERAPIS (*c.*215), which had 12 columns across its 25-m-high (81-ft) facade. Emperor Aurelian's enormous Temple of the Invincible Sun (*c.*275), a round structure set within a rectangular enclosure, was the last important temple built in Rome.

India. The Maurya emperors (r. 322–185 BC) are the earliest-known temple builders in India (see INDIAN ART AND ARCHITECTURE). Emperor ASOKA, the most renowned patron of early Buddhism, sponsored the construction of thousands of STUPAS—brick-faced, domical mounds containing the relics of the Buddha—as well as rock-cut basilical temples known as chaityas. As they evolved, chaityas developed into colonnaded halls of worship housing the Buddha's image, which had become an integral part of the Buddhist temple. The chaitya at Karli (*c.*80 BC) is representative of this phase of chaitya building.

During the brilliant Gupta period (320–647), the Buddhist temple form culminated in elaborate, freestanding brick chaitya halls such as that at Chezarla (4th–5th century). Unprecedented square-plan temples, apparently derived from civil meeting halls, appeared at Ladh Khan (*c.*450) and elsewhere.

Of the three main types of Hindu temple—*nagara, dravida*, and *vesara*—the *nagara* is the oldest and the most important. Conical or convex in shape, the *nagara* is crowned with a spire known as a *sikhara*; a representative example is that at Galanganatha (7th century). The *dravida*, on the other hand, consisted of a series of ascending terraces, or *bhumis*, representing the hierarchy of the divinities; on each terrace is a *stupika*, or "little stupa." Typical *vesaras*, such as Bhima's Rath (625–74) in MAHABALIPURAM, were barrel-vaulted halls derived from Buddhist chaitya halls. The peak of Hindu temple building occurred in about 1000, when the opulently embellished *nagara* temples of KHAJURAHO were erected. Echoing the ornate sculptural decoration of later Hindu shrines were the fantastic white-marble temples of the Jain religion built at Mount Abu from the 10th to the 13th century.

Cambodia. Under the Khmer Empire, centered in modern-day Kampuchia, temple architecture reached new heights in the period between AD 800 and 1450. At the Khmer capital of ANGKOR two great temple complexes dedicated to Vishnu, but reflecting Hindu influences, were built in the 12th century. Angkor Wat, built (1st half of the 12th century) by Emperor Suryavarman II, has been called the world's largest religious structure. Perhaps the most stunning aspect of this huge complex is the magnificent low-relief sculptural decoration that covers its miles of walls. At the nearby temple complex of the Bayon (late 12th–early 13th century) in Angkor Thom, erected by Emperor Jayavarman VII, even more elaborate sculptural decoration adorns the architecture.

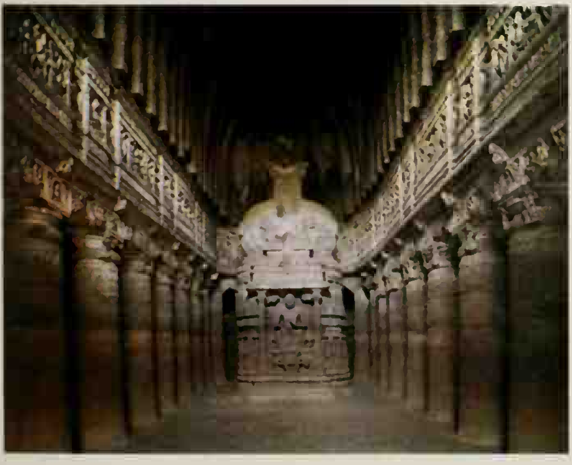
Indonesia. Hindu and Buddhist temples vied for dominance in 9th-century Java and Sumatra. Indian influence is apparent in the greatest Javanese monument, the enormous temple of BOROBUDUR (8th century). The nine-level circular stupa, which surmounts a square stepped pyramid and is crowned with a lofty spire, is decorated with reliefs that illustrate in successive stages the process of Buddhist enlightenment.

China. Chinese temples, unlike those of India or Southeast Asia, traditionally were made of wood—a fact that accounts for the relatively small number of structures that have survived (see CHINESE ART AND ARCHITECTURE). Temple construction dates back at least to the Zhou dynasty (1027–256 BC). From the time of the Han dynasty (202 BC–AD 220), almost all Chinese temple complexes, regardless of the religion represented, follow the same basic plan of an open courtyard flanked on three sides by identical buildings and on the fourth side by a ceremonial gate. Many Daoist shrines were erected by Han emperors, but the greatest stimulus for temple building under the Han occurred when Buddhism was introduced (1st century AD) from India. Along with Buddhism came a variation of the Indian stupa form, on which the PAGODA—a tower composed of superimposed stories with overhanging roofs—was based.

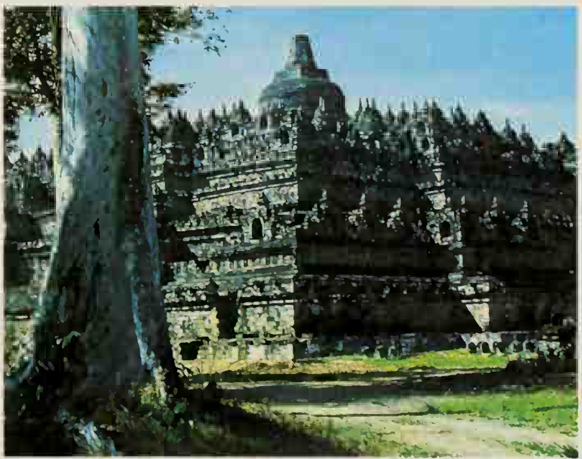
Buddhism flourished under the Six Dynasties (221–589). There were 42 pagodas in Luoyang under the Jin (265–317); by the time of the Northern Wei (386–534) there were more than 500 in Luoyang alone and about 30,000 throughout Northern China. The usual number of stories increased from 3 in the 4th century to 5 in the 6th century, and Wudi of Liang built (535) a 12-story pagoda that reputedly was about 122 m (400 ft) tall. These pagodas are imitated in the surviving rock-cut temples of YUNGANG (late 6th century).

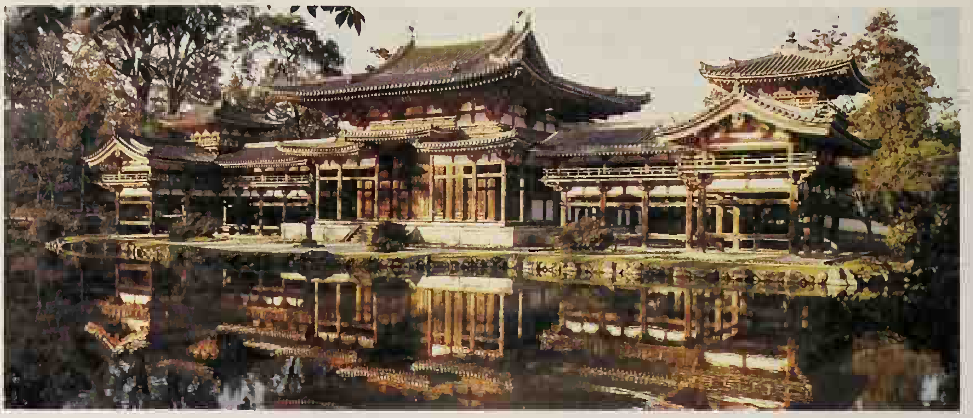
Under the Sui (581–618) and Tang dynasties (618–906) imperial-scale building became the rule. The major temple form of this era was a complex consisting of two

This chaitya (vaulted hall; AD 600–42) is one of 29 Buddhist cave sanctuaries carved into a cliff at Ajanta, India, dating from the 2d century BC to the 7th century AD.



The shrine (AD c.800) at Borobudur in Java is a unique example of Buddhist temple architecture. The pyramidal monument is surmounted by a circular stupa consisting of nine levels.





The Hoodo, or Phoenix Hall, part of the Byodoin temple in Uji, near Kyoto, Japan, dates from the late Heian period. The temple complex was originally a family villa and was converted into a temple sanctuary in 1052. The Hoodo has a central pavilion, connecting galleries, and corner pavilions.

pagodas for relics and a central worship hall for the images of Buddha. Although other buildings in the temple complexes remained wooden, the use of masonry in pagodas became common.

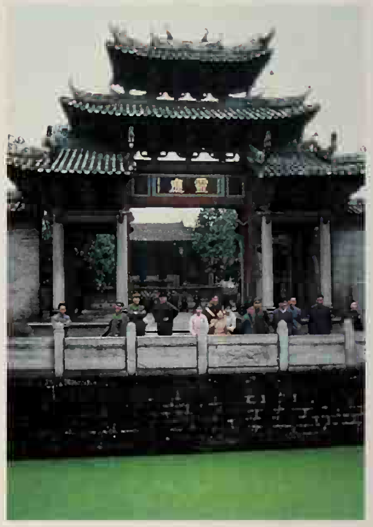
In the Five Dynasties (907–60) and Song (960–1279) periods, temple building prospered, then declined as the emperors embraced the ascetic Chan Buddhist sect. Song pagodas tend to be hexagonal or octagonal structures made of brick, as exemplified by the 13-story Tieta (*c.*1044) at KAIFENG. The succeeding Yuan dynasty (1279–1368) further developed the Song temple-types into a three-stage division: a high base, a shaft, and a crown. Bases are octagonal and decorated with sculpture, as are the shafts, and crowns generally are composed of 13 close-set roofs.

Japan. The earliest-known Japanese temples were wooden Shinto shrines—largely unornamented and gabled-roofed sanctuaries that looked like granaries or houses (see JAPANESE ART AND ARCHITECTURE). The interior generally contained an off-axis sacred chamber and a central pillar that symbolized the pillar of heaven. Each temple stood within an enclosure entered through elaborately decorated gateways, or *torii.*

The first Buddhist temple in Japan was built (552) to house a gilded bronze statue of the Buddha presented to Emperor Kimmei by the Korean king of Paekche. Unlike Chinese examples, Japanese Buddhist shrines were relatively simple sanctuaries consisting of the pagoda to shelter relics, and an assembly hall, or *kondo,* for worship of the Buddha's image.

After the Golden Hall of the Horyuji was created (*c.*607) at Nara, temples became larger and more magnificent complexes. Foundations grew even larger, rivaling those of Tang China. Particularly impressive was the huge monastery of Todaiji (begun 745), which demonstrated the primacy of the *kondo* and the removal of the pagodas from the sanctuary proper.

The Heian period (784–1185) marked a revival of Japanese, as opposed to Chinese, forms and ritual-centered Tantric Buddhism became preeminent. The greatest sanctuary built in this era was the Hoshoji (1077) of Heian (now Kyoto), whose octagonal, nine-story pagoda was located on an island on axis with the *kondo.* In Tantric temples, rites had to be performed in secret but with the congregation present; this requirement led to the development of forehalls in Tantric *kondos,* such as that at Koryuji (*c.*818).



(Right) *The Zu Shi Miao temple in Guangzhou (Canton), China, possesses the same overall plan of other Daoist temples, which are simpler and comprise fewer buildings than Buddhist temples. The temple is designed with an open courtyard, flanked on three sides by identical buildings and on the fourth side by a ceremonial gate.*

Because it was closely associated with the Zen sect, which gained many adherents in Japan in the 13th century, the Karayo style flourished throughout the country. Its principal innovation was an elevated shrine in the *kondo.* Also widespread was a progressive Japanese style, the Wayo.

The later Japanese periods (1333–present)—Muromachi, Momoyama, and Edo—displayed eclecticism and modesty of scale. Southward orientation, frequent in earlier periods, gave way, with the emergence of the Shin sect, to eastern orientation. Representative of this later style was the Honganji Temple (1585) at Kyoto, a shrine of the Shin sect.

Temple, Shirley A phenomenal child sensation in movies of the 1930s, Shirley Temple, b. Santa Monica, Calif., Apr. 23, 1928, became well known in the 1970s for her political activism on behalf of the Republican party. During the Depression, however, her curls, her dimples, and her undoubted talent in such films as *Little Miss Marker* (1934), *The Little Colonel* (1935), *Captain January* (1936), *Wee Willie Winkie* (1937), *Heidi* (1937), *Rebecca of Sunnybrook Farm* (1938), and *The Little Princess* (1939) completely captivated America. She retired from films in 1949 after a series of unremarkable teenage and adult roles. As Mrs. Shirley Temple Black, the former star served as a delegate to the United Nations (1969), as U.S. Ambassador to Ghana (1974), and as U.S. Chief of Protocol (1976) in the Ford administration.

Shirley Temple, America's most popular child star of the 1930s, curtsies in this publicity photograph. After retiring from films, Temple became active in politics. She has been appointed as a representative to the United Nations General Assembly (1969) and ambassador to Ghana (1974) and Czechoslovakia (1989).

Temple, William (archbishop) William Temple, b. Oct. 15, 1881, d. Oct. 26, 1944, archbishop of Canterbury (1942–44), was a noted theologian and leader of the ecumenical movement. The son of Frederick Temple, archbishop of Canterbury (1896–1902), he was consecrated bishop of Manchester in 1921, archbishop of York in 1929, and archbishop of Canterbury in 1942. Noted as a champion of social and economic justice, Temple was first president of the Workers' Educational Association.

Temple, Sir William (essayist) An English diplomat and essayist whose prose style was greatly admired, Sir William Temple, b. Apr. 6, 1628, d. Jan. 27, 1699, played a leading part in negotiating the anti-French TRIPLE ALLIANCE (1668) with the Netherlands and in 1677 helped to arrange the marriage of William of Orange and Mary, the niece of Charles II. With *Upon Ancient and Modern Learning* (1690), Temple introduced into England the French debate on the virtues of classical as opposed to "modern" literature, later satirized by Temple's onetime secretary, Jonathan Swift, in *The Battle of the Books*.

tempo The tempo, or rate of speed, of a piece of music is determined by its character, the physical conditions of performance, and the instructions transmitted by the composer. Before the 17th century, performers knew the correct tempo from the notation, for note values were related to tempo. The adoption of time signatures and tempo marks made possible a variety of durations for any note. The time signature 3/4 gave a quarter note one pulse; 3/2 gave it half a pulse; 4/8 gave it two pulses. The rate at which these pulses occurred could be modified by the use of tempo markings, such as allegro or andante. A high degree of accuracy in tempo indications was made possible by the invention of the metronome, a device that shows the number of beats per minute. Composers have been inconsistent in their use of it, however, and conductors have often modified a composer's indications, either because of a different interpretation of the composition or because of the conditions under which it is performed.

Ten Commandments A basic set of divine laws in the Bible, also called the Decalogue (from the Greek *deka*, "ten," and *logos*, "word"), the Ten Commandments form the fundamental ethical code of Judaism, Christianity, and Islam. According to the biblical narrative, God gave the commandments to MOSES on Mount Sinai and inscribed them on two stone tablets. Moses broke the tablets in anger when he found his people worshiping the GOLDEN CALF, but eventually he replaced them and enshrined them in the ARK OF THE COVENANT. Two slightly different versions of the commandments are found in Exodus 20:1–17 and Deuteronomy 5:6–21.

Two traditions are also adhered to for listing the commandments. Lutherans and Roman Catholics consider the opening prohibitions against false worship as one commandment, whereas most other Protestants and the Eastern Orthodox follow the Hebrew tradition of dividing them into two. The latter maintain the number at ten by combining the final prohibitions against covetousness.

The opening commandments concern reverence for the one God, who will tolerate no rivals; the making and worship of graven images is forbidden, as is taking God's name in vain; and observance of the Sabbath is enjoined. The other commandments regulate human relationships: the injunctions to honor one's parents and the bans on killing, adultery, stealing, false witness, and covetousness.

Ten Lost Tribes of Israel Old Testament tradition traces the origin of the Jewish people to 12 tribes. At the death (*c.*920) of King Solomon, the tribes split into two kingdoms: the tribes of Judah and Benjamin formed the southern kingdom of Judah, and the remaining ten constituted the northern kingdom of Israel. When Israel was conquered by the Assyrians in 722–21 BC, the ten tribes as organized entities disappeared from the stage of history.

Many of the members of the ten tribes were apparently deported to Assyria and eventually became part of the worldwide Jewish Diaspora. Others probably merged into the Gentile population of the empire.

Ten Years' War The Ten Years' War (1868–78), an unsuccessful guerrilla campaign against Spanish rule in Cuba, laid the groundwork for the eventual freedom of Cuba (1898). Native Cubans had long resented Spain's arbitrary treatment of the colony. Taking advantage of revolutionary ferment in Spain, Carlos Manuel de CÉSPEDES and his followers declared Cuban independence in October 1868. The provisional government soon controlled the eastern half of the island and attracted widespread support.

The bloody war dragged on for nearly 10 years. Guerrilla tactics were used against the Spanish army that arrived in 1876, but no decisive battles were fought. The war ended in 1878, when Spain, by the Pact of El Zanjón, promised amnesty and political reform. Complete emancipation of slaves was eventually granted, but many other promises were broken. Cuban rebels once again took up arms in 1895 and achieved independence three years later.

tenant A tenant is a person who holds lands or tenements (buildings or dwellings) by any kind of TITLE or right, whether permanently or temporarily. More commonly, a tenant is one who has the temporary use of a house or apartment owned by another person (the landlord), with a LEASE usually spelling out the duration and terms of the lessee's tenancy.

Legally, the idea of tenancy is used in different ways, such as tenancy for a fixed period, tenancy at will, and tenancy at sufferance (or hold-over tenancy). Tenancy for a fixed period means that the tenant (or lessee) can, upon the payment of rent, occupy a house or apartment for a stated period of time, according to the terms of the lease. Tenancy at will is a rental agreement in which the tenant can occupy a house or apartment for an indefinite period. Either party can end the agreement at any time but usually only upon proper written notice. Most states have statutes governing the time necessary for notice of termination to be given. Tenancy at sufferance (hold-over tenancy) takes effect if a tenant occupies a house or apartment beyond the time period specified in the lease. A tenant at sufferance is not a trespasser, because he or she originally occupied the premises with the landlord's permission. Upon entering the premises and demanding possession, however, the landlord can sue the tenant for trespass and evict the tenant.

A tenant usually cannot sublease a house or apartment to another person (a subtenant) without the written permission of the landlord. If a tenant sublets by permission, he or she still remains responsible for the subtenant's obligations to the landlord, unless the landlord has signed an agreement releasing the tenant from responsibility.

tendon Tendons are bands of tough, ropelike connective tissue joining muscles to bones or cartilage and transmitting the force of MUSCLE CONTRACTION to move skeletal parts. Consisting of closely packed, parallel bundles of white collagen fibers, tendons are resistant to extension but quite flexible and strong. They therefore can be angulated around bone to change the final direction of the pull during the muscle contraction.

Like an arm in a sleeve, tendons slide up and down within a sheath of fibrous material called the vagina fibrosa. Inside this sheath is a fine network of lymphatic vessels and a small amount of fluid to facilitate tendon movement by reducing friction. The entire structure is bound in place by small projections of connective tissue. Tendons vary in shape and size; they are attached either directly to the bone by projecting fibrils or to the periosteum.

tendonitis Tendonitis (or tendinitis) is an inflammation of the lining of a tendon's sheath and the enclosed tendon. In calcific tendonitis, a common cause of shoulder pain, calcium deposits in tendons near the shoulder joint cause secondary inflammation of a nearby fluid-filled sac, called a bursa. The bursa may rupture and be invaded by an inflammatory fluid containing insoluble calcium salts, a condition known as BURSITIS. Surgery for removal of large calcium deposits is required in only a few cases. Drugs are often prescribed for the relief of pain and inflammation of tendonitis.

Tenerife see SANTA CRUZ DE TENERIFE

Teng Hsiao-p'ing see DENG XIAOPING

Teniers, David, the Younger [tuh-neerz' or ten'-yurz] The Flemish painter and engraver David Teniers the Younger, b. December 1610, d. Apr. 25, 1690, was a master of genre subjects and the most distinguished member of a large family of painters. Until 1638 he was principally influenced by the sometimes violent peasant scenes of Adriaen Brouwer—as in *The Barn* (1634; Staatliche Kunsthalle, Karlsruhe, Germany)—and maintained a close connection with Dutch art. Teniers's genre scenes are usually more detached and genteel, with a greater refinement and delicacy of color. He was skilled at the depiction of everyday rural events, as in *Village Fête* (1646; Hermitage, Leningrad), but he also painted religious and mythological subjects. About 1651, Teniers moved to Brussels, where he served as court painter, tapestry designer, and curator of paintings to the Spanish regent, Archduke Leopold William.

Tennent, Gilbert Gilbert Tennent, b. Ireland, Feb. 5, 1703, d. July 23, 1764, the son of William Tennent, was a Presbyterian leader of America's first widespread religious revival, the GREAT AWAKENING. While a minister in New Brunswick, N.J. (from 1726), Tennent came under the influence of a neighboring Dutch Reformed minister, Theodore Frelinghuysen, who taught that religion was to be a matter of the heart as well as the mind. With George

Whitefield and others, Tennent traveled extensively on evangelistic missions during 1740 and 1741. His sermon "The Dangers of an Unconverted Ministry" (1740) was one of the factors leading to a rupture of colonial Presbyterianism into the New Side (prorevival) and the Old Side (traditionalist) factions. Tennent, who moved to Philadelphia in 1743, eventually moderated his views and was instrumental in the reuniting of the Presbyterians in 1758.

Tennent, William A Presbyterian minister and founder of the Log College, William Tennent, b. Ireland, 1673, d. May 6, 1746, served his denomination for nearly 30 years. Ordained (1706) an Anglican priest, he joined the Presbyterian ministry after immigrating to Pennsylvania about 1718. Near his church in Neshaminy, Pa., Tennent founded a school, the Log College, to train evangelical ministers. His students became a dynamic force in developing American Presbyterianism and extending the Great Awakening, and his school was the forerunner of other institutions, notably the College of New Jersey (1746; now Princeton University). William was the father of Gilbert Tennent.

Tennessee Tennessee, a southeastern state, stretches about 770 km (480 mi) from the Appalachian Mountains in the east to the Mississippi River in the west. It is bounded by Kentucky and Virginia on the north; North Carolina on the east; Georgia, Alabama, and Mississippi on the south; and Arkansas and Missouri on the west. Tennessee was named for the great river that cuts through the state, although the meaning of the word *Tennessee* is unknown. From its rough frontier origins Tennessee played an important role in the nation's history even before statehood in 1796. Tennessee gained its nickname, The Volunteer State, from the large numbers of soldiers it sent to the Revolutionary War, the War of 1812, the Mexican War, and the Civil War. Today Tennessee is a prosperous state, with much industrial and agricultural potential.

Land and Resources

Tennessee is traditionally divided into East, Middle, and West Tennessee. East Tennessee extends from the Great Smoky Mountains across a series of elongated ridges and valleys into the Cumberland Plateau. In Middle Tennessee the Nashville Basin is rimmed by a heavily carved upland, and West Tennessee contains the Coastal Plain and the Mississippi Bottoms.

The physical environment is extremely varied. The Great Smoky Mountains rise to elevations exceeding 1,830 m (6,000 ft). Clingmans Dome, at 2,025 m (6,643 ft) the highest point in Tennessee, is the second highest

AT A GLANCE

TENNESSEE

Land: Area: 109,158 km^2 (42,146 mi^2); rank: 36th. Capital: Nashville-Davidson (1990 pop., 510,784). Largest city: Memphis (1990 pop., 610,337). Counties: 95. Elevations: highest—2,025 m (6,643 ft), at Clingmans Dome; lowest—54 m (178 ft), at the Mississippi River.

People: Population (1990): 4,896,641; rank: 17th; density: 45.7 persons per km^2 (118.3 per mi^2). Distribution (1990): 60.9% urban, 39.1% rural. Average annual change (1980–90): +0.6%.

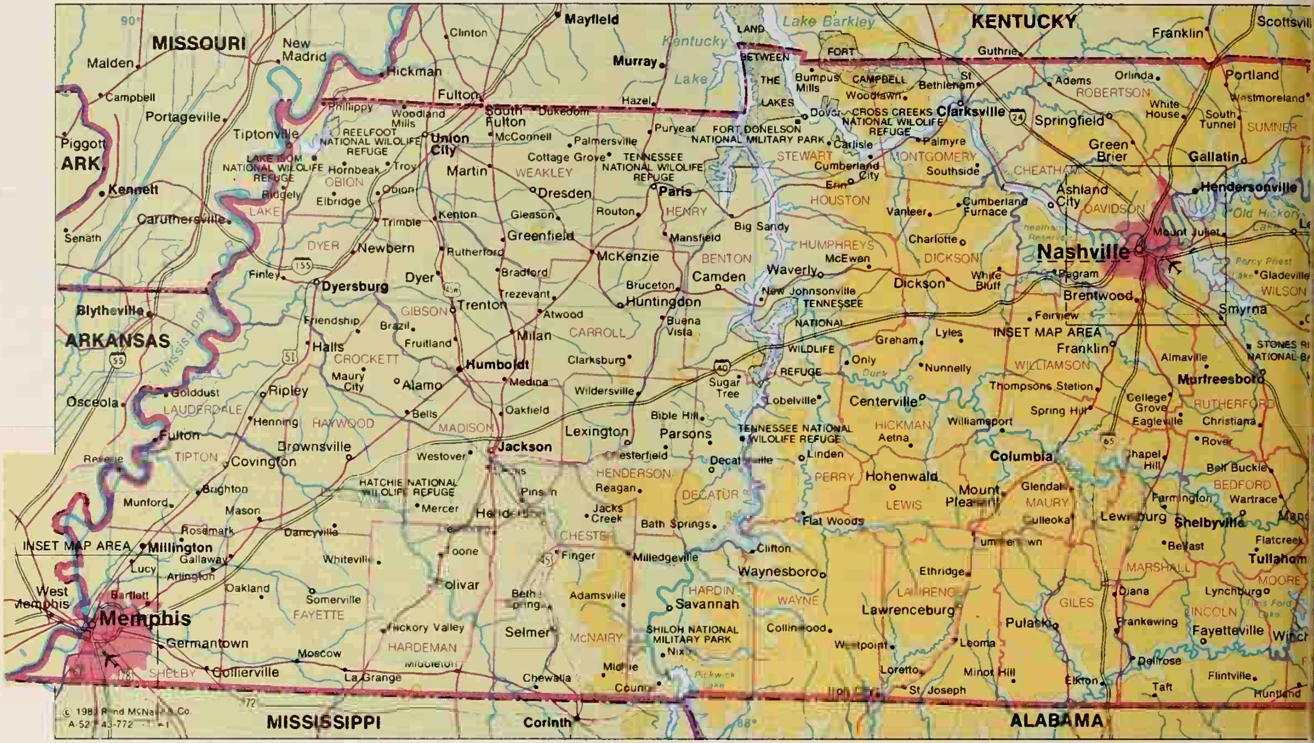
Government (1993): Governor: Ned McWherter, Democrat. U.S. Congress: Senate—2 Democrats; House—6 Democrats, 3 Republicans. Electoral college votes: 11. State legislature: 33 senators, 99 representatives.

Economy: State personal income (1989): $72.6 billion; rank: 21st. Median family income (1989): $29,546; rank: 38th. Agriculture: income (1989)—$1.9 billion. Lumber production (1991): 519 million board feet. Mining (nonfuel): value (1988)—$586 million. Manufacturing: value added (1987)—$27.1 billion. Services: value (1987)—$17.8 billion.

Miscellany: Statehood: June 1, 1796; the 16th state. Nickname: Volunteer State; tree: tulip poplar; motto: Agriculture and Commerce; songs: "The Tennessee Waltz," "When It's Iris Time in Tennessee," "My Tennessee," "My Homeland, Tennessee," "Rocky Top."

Mockingbird

Iris



point east of the Mississippi River. Eastward from the mountains the Ridge and Valley Province consists of layers of limestone, sandstone, dolomite, and shale, which were crumpled into elongated mountains 400 million to 350 million years ago. The mountains' erosional remnants are the present northeast-southwest trending ridges and intervening valleys. The ridges reach 799 m (2,620 ft) in elevation, and the valleys descend to 195 m (640 ft). Westward of the Ridge and Valley, the Cumberland Plateau varies in width from 80 to 113 km (50 to 70 mi) and in height from 610 to 1,067 m (2,000 to 3,500 ft). Its limestone and sandstone rocks have been deeply cut by streams. A spectacular entrenchment about 7 km (4.5 mi) wide and 113 to 129 km (70 to 80 mi) long called the Sequatchie valley occupies the southeastern margin of the plateau.

The plateau drops off sharply to the west into the Nashville Basin. The basin, a rolling, rocky, oval-shaped lowland, averages about 183 m (600 ft) in elevation. It extends approximately 129 km (80 mi) north-south and 80 km (50 mi) east-west. It is surrounded by the Highland Rim, which, with the basin, was eroded from the plateau surface. The Highland Rim stands about 61 to 122 m (200 to 400 ft) higher than the basin and is 32 to 97 km (20 to 60 mi) wide. Most of the surface is gently to steeply sloping.

Farther west is the coastal lowland of West Tennessee. The rocks there are younger, and the surface more level, than any other region in the state. In the northwestern part of Tennessee is Reelfoot Lake, a shallow body of water created in 1811–12 by the New Madrid earthquake.

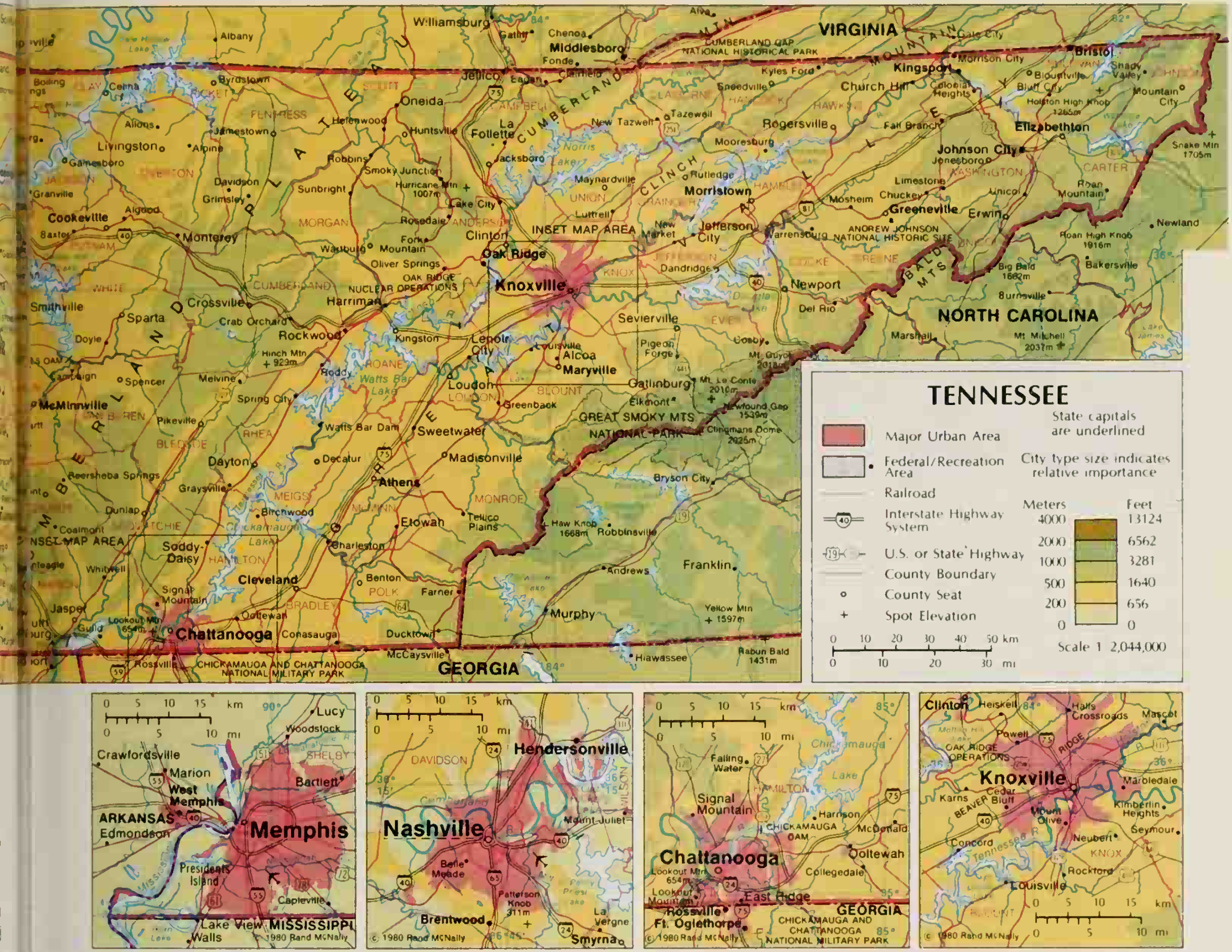
Soils. Most of Tennessee's soils are thin and rocky, with deeper deposits occurring in the plains of West Tennessee and in eastern valleys. The steeply sloping areas are subject to heavy erosion and have low natural fertility. Near the Mississippi River are thick deposits of loess.

Climate. Tennessee's climate is transitional between the long, hot summers and mild winters farther south and the more severe winters and shorter summers of the Middle West. January temperatures average 5° C (41° F) in the west and 3° C (37° F) in the east. July temperatures average 26° C (79° F) in the west and 22° C (71° F) in the east. The eastern mountains receive more precipitation (1,270–1,525 mm/50–60 in) than any part of the continental United States except the Pacific Northwest. Statewide precipitation averages 1,270 mm (50 in).

Rivers and Lakes. Drainage in much of the state is partially below the surface. The Tennessee River and the Cumberland River both make wide loops from Kentucky into Tennessee and back again, emptying into the Ohio River. The rivers of West Tennessee drain directly into the Mississippi River.

Vegetation and Resources. More than half of Tennessee is forested. East Tennessee contains a mix of hardwoods and softwoods, whereas most other areas are dominated by hardwoods. Cedar trees are prominent in the Nashville Basin. The once-abundant wildlife is now strictly protected.

Stone, coal, zinc, sand, gravel, phosphate rock, cop-



per, and clays are the leading minerals by value. Barite, sulfur, and lime are also important, but water is Tennessee's most highly developed resource. The Tennessee Valley Authority changed the Tennessee River and its major tributaries from flood-prone streams into a series of quiet reservoirs behind concrete and steel dams.

People

More than 60% of Tennessee's population is urban. Nashville-Davidson is the capital, and Memphis is the state's largest city. Other major cities are Knoxville and Chattanooga.

Although Tennessee has traditionally been a state of high birthrates and substantial out-migration, that trend has been reversed since 1973. More people now migrate into than out of the state.

Blacks account for 16% of the population (1990), with heaviest concentrations in the greater Memphis area. Most Tennesseans are predominantly of German, English, or Italian extraction. The religious denomination with the largest membership is the Baptist church, followed by the Churches of Christ, Methodist and Presbyterian churches, and Church of the Nazarene.

Education. A statewide tax-supported school system was established in Tennessee in 1873. Not until 1909, however, was the program effectively funded. Public institutions of higher education include the University of Tennessee (1794), with its main campus at Knoxville and various branches statewide. Additionally, other state universities and community colleges operate under a Board of Regents. Prominent private universities are Vanderbilt University in Nashville and the University of the South (1857) in Sewanee.

The largest book collection in Tennessee is housed in the Joint Universities Libraries (a pooling of collections from Vanderbilt University, Peabody College, and Scarritt

The observation tower atop Clingmans Dome (2,025 m/6,643 ft), the highest point in Tennessee, affords a spectacular view of the surrounding Great Smoky Mountains National Park.

College) in Nashville. The second largest collection is that of the University of Tennessee Libraries in Knoxville. The state's public libraries house several million volumes.

Cultural Attractions and Historic Sites. Tennessee's state museum is housed in the War Memorial Building in Nashville. The American Museum of Science and Energy in Oak Ridge contains a major collection of technology. Nashville, home of the GRAND OLE OPRY, is the nation's center for country and western music. The Parthenon (1897) in Nashville is an exact replica of the Greek Parthenon in Athens.

The Hermitage (Andrew Jackson's home near Nashville), the Andrew Johnson National Historic Site near Greeneville, the several Civil War battlefields at Lookout Mountain, Shiloh, Chickamauga, and Murfreesboro, and the CUMBERLAND GAP National Historical Park are among the major historical sites. Knoxville's Blount Mansion (1792) and the Memphis home of Elvis Presley are also favorite attractions for visitors.

Great Smoky Mountains National Park draws millions of visitors each year. Pinson Mounds, near Jackson, has outstanding archaeological sites and the remains of an Indian city.

Communications. Tennessee has a number of daily newspapers. The *Memphis Commercial Appeal* has the largest circulation, followed by the *Nashville Tennessean*. Commercial broadcasting is conducted through many radio and television stations.

Economic Activity

From its agricultural beginnings, Tennessee has become increasingly industrialized. As the economy diversifies, median incomes and standards of living rise, although the per capita income has remained below the national average.

Manufacturing. Manufacturing accounts for about one-quarter of the gross state product. The major industries in the state are those producing chemicals, electrical equipment, processed foods, nonelectrical machinery, fabricated metals, transportation equipment, rubber and plastic products, furniture, and textiles. Manufacturing centers are in Memphis, Nashville, Knoxville, and Chattanooga.

Agriculture. Tennessee's best agricultural lands are in the coastal lowlands near the Mississippi River. Agriculture employs only a small percentage of the state's labor force. Livestock products account for about half of all farm income, and cattle is the leading commodity. Tennessee is also a leading dairy state in the south. The major crops are soybeans, tobacco, cotton, and corn. Horses are also raised, primarily in Middle and West Tennessee.

Mining, Forestry, and Fishing. Tennessee's major mineral resources are bituminous coal, stone, and zinc. Tennessee ranks first among U.S. states in the production of zinc. The state's commercial timberland is 90% privately owned. Commercial fishing is of negligible importance, but sport fishing is popular.

Energy. The giant Tennessee Valley Authority (TVA), an agency of the federal government, is the nation's largest power-generation system and generates almost all of Tennessee's electrical power. Most of that power is generated from coal-burning plants; the remainder comes from hydroelectric facilities.

Transportation. Memphis, Nashville, Knoxville, and Chattanooga are major junction points for the interstate highway network as well as rail-, water-, and air-transportation centers. The Mississippi River forms Tennessee's western border and is a major navigational route, as is the Tennessee-Tombigbee Waterway, linking Tennessee cities with ports on the Gulf of Mexico. Memphis International Airport is the state's major air terminal.

Government

Government in Tennessee operates under a constitution adopted in 1870 and amended several times. The governor is elected to a 4-year term and may serve only two consecutive terms. The General Assembly consists of a house of representatives with 99 members elected to 2-year terms and a senate with 33 members elected to 4-year terms. Each of Tennessee's 95 counties is governed by a county court composed of a county judge and several magistrates. The 5 Supreme Court justices, although theoretically elected, usually serve until death or retirement. Most cities and towns have a mayor-council form of government. A metropolitan government has been adopted by Nashville-Davidson County.

Tennessee has always been divided politically—as well as socially and economically—between east and west. East Tennessee is a Republican bastion, and West and Middle Tennessee are strongly Democratic.

History

The earliest-known inhabitants of Tennessee were MOUND BUILDERS, and when Europeans penetrated the area they found that these Indian groups were still present. The Spanish explorer Hernando DE SOTO was the first European to enter what is now Tennessee. He crossed the state and discovered (1541) the Mississippi River near present-day Memphis. At that time the CHEROKEE Indians inhabited East Tennessee; the SHAWNEE, Middle Tennessee; and the CHICKASAW, West Tennessee.

Both France and England claimed parts of the territory during the 17th and 18th centuries, but in 1763 the French relinquished all lands east of the Mississippi to England, and permanent European settlement began. In 1772 the settlers in a few isolated centers organized themselves into the Watauga Association for protection and administration of justice. Two leaders of this association were John SEVIER and James ROBERTSON, who founded (1779) a community near present-day Nashville.

The Tennessee pioneers joined in the American Revolution, and forces led by Sevier and Isaac SHELBY were instrumental in winning the Battle of Kings Mountain (Oct. 7, 1780).

Following the Revolution and numerous skirmishes with the Cherokees for control of the territory, the State of FRANKLIN was formed (1784) in eastern Tennessee out of land ceded by North Carolina to the federal government. North Carolina refused to recognize the new state, however, and Sevier, Franklin's governor, was arrested in 1788 and the new state collapsed. North Carolina again ceded its western territory in 1789, and President Washington commissioned (1790) William BLOUNT governor of all U.S. territory south of the Ohio River. On June 1, 1796, Tennessee became the 16th state; Sevier was its first governor.

In the War of 1812, Tennessee supplied 28,000 troops and had more soldiers than any other state in the Battle of New Orleans, won by native son Andrew JACKSON. Tennessee furnished most of the men and the commanders for the ensuing Indian wars east of the Mississippi. Among the state's famous Volunteers were Davy CROCKETT, who died at the Alamo, and Gen. Sam HOUSTON, who became the first president of the Republic of Texas.

At the outbreak of the Civil War, Tennessee was torn between the nearly unanimous support of the Union in the abolitionist East and equally strong support of the Confederacy in the slave-holding Middle and West. As a result Tennessee was the last Southern state to secede. Because of its position as a border state, more battles of the Civil War were fought on Tennessee territory than any other state except Virginia. After the Union victories at Fort Donelson and Fort Pillow, Tennessee was placed under military rule, with Andrew JOHNSON as military governor. After the war Tennessee was the first Confederate state to be readmitted to the Union, but Reconstruction proved to be a difficult period in the state's history.

After the Civil War, agriculture made only a slow revival as the state's economic mainstay, and the ongoing process of industrialization began. In addition to the losses of the war, the population of Memphis was nearly wiped out by a yellow-fever epidemic in 1878.

The tiny town of Dayton became the center of national attention in 1925 when the famous SCOPES TRIAL brought together William Jennings Bryan and Clarence S. Darrow in a bitter lawsuit concerning the teaching of Darwin's theory of evolution. The case was a test of a Tennessee statute (1925) prohibiting the teaching of evolution (which offended religious fundamentalists) in the state's public school system. The challenge was unsuccessful, and the law remained on the books until 1967.

Desegregation of public schools proceeded slowly but without serious incident in Tennessee. On Apr. 4, 1968, the Rev. Martin Luther King, Jr., was assassinated in Memphis.

Today Tennessee still has its traditional contrasts between the industrialized east and the more agricultural west. These distinctions are now more a source of strength than conflict, however. In-migration to the state is increasing; Tennessee should, therefore, be able to profit from its location in the Sun Belt and gain new industry and a better standard of living for its citizens.

Tennessee River The Tennessee River, one of the principal rivers of the southeastern United States and a major tributary of the OHIO RIVER, flows in a half circle through the states of Tennessee, Alabama, and Kentucky. Formed by the Holston and French Broad rivers near Knoxville, Tenn., it empties into the Ohio at Paducah, Ky., after a course of 1,049 km (652 mi); it drains an area of about 105,150 km^2 (40,600 mi^2). Principal tributaries include the Little Tennessee, Hiwassee, Paint Rock, Duck, Clinch, Flint, and Elk. The river was an important route for the invasion of Confederate territory by Union forces during the Civil War (see FORT HENRY AND FORT DONELSON). After the Tennessee Valley Authority was established in 1933, a series of dams, reservoirs, and locks harnessed the river for power, flood control, and navigation. Late in 1984 the $2-billion Tennessee-Tombigbee Waterway was completed. It connects the Tennessee, in northeast Mississippi, with the Gulf of Mexico at Mobile, Ala., via a 377-km-long (234-mi) system of canals and locks along the Tombigbee River.

Tennessee Valley Authority The Tennessee Valley Authority (TVA) is an agency of the United States designed to foster development in the Tennessee River Valley and certain adjacent territories. The TVA extends over large areas in seven states: Tennessee, North Carolina, Virginia, Georgia, Alabama, Mississippi, and Kentucky. It was created by the U.S. Congress in May 1933 as a major feature in the New Deal administration of Franklin D. Roosevelt. Its creation grew from the need to use the World War I hydroelectric and related facilities in north Alabama as well as to provide navigation and flood control on the Tennessee River.

The authority's tasks include flood control, the promotion of navigation from the river mouth to Knoxville (about 1,050 km/650 mi), and the production and sale of electric power. The TVA has also improved farm and forestry practices, produced and distributed fertilizer, and fostered recreational facilities, including the Land Between the Lakes National Recreation Area.

Although opposition to the TVA was expressed by private power companies and by conservatives who opposed government involvement in general, the production and sale of hydroelectric power was justified legally as a byproduct of flood-control and navigation dams. Nevertheless, hydroelectric production is no longer the major source of the power produced by the TVA. In 1991, of a total system capacity of 32,164 megawatts (MW), hydro capacity was about 10% of total capacity; coal-fired, 55%; combustion turbine, 8%; and nuclear, 18%. The system capacity owned by ALCOA, Inc., and the Army Corps of Engineers was 4% of total capacity, and the pumped-storage capacity was about 5%.

The TVA's dams form an integrated system that aids flood control on the Tennessee, Ohio, and Mississippi rivers. As of 1991 the TVA system was operating 49 dams that it has built or acquired since 1933; of these, 29 were power producing. Forty of these dams are located in the Tennessee River Basin and 9 in the Cumberland River Basin.

The TVA is governed by a three-member board appointed by the president with consent of the Senate; the president designates one member to chair the authority.

The TVA made cooperation with the states and localities a major feature of its policy, particularly in agriculture. In its power operations it has paid little attention to states; power is distributed to large industries and to municipalities and rural cooperatives. The TVA seeks to enlarge power usage at the lowest feasible rates.

The TVA is financed by appropriations, earnings, and borrowing. Flood-control and navigation operations and similar functions are supported by appropriations in accordance with practice elsewhere. Prior to 1959 most of the money for dams and steam plants was provided by appropriations; proceeds from bonds up to that time were used to buy properties from other systems. The TVA is now authorized to borrow funds for the purpose of constructing power facilities. Revenues from power operation pay power-operating expenses. Beginning with fiscal year 1961 the TVA was required to make a return to the U.S. Treasury on its investment in power facilities. The TVA divides among the states in its area an amount equal to 5% of its gross power revenues of the preceding year, and it makes payments to states and counties equal to their former property taxes on TVA property.

Long opposed by conservatives favoring private development, the TVA came under fire from a new quarter during the 1970s. Environmentalists opposed the TVA's use of strip-mined and polluting coal and its operation of nuclear power plants. They charged that the federal government was generally insensitive to environmental needs in its commitment to growth and development and that the TVA had promoted energy-intensive industry in a time of incipient energy shortage. The Tellico Dam, held up for several years because of environmental issues, embroiled the TVA in national controversy. During the 1980s safety problems beset TVA's nuclear power facilities. The two operational plants were temporarily shut down.

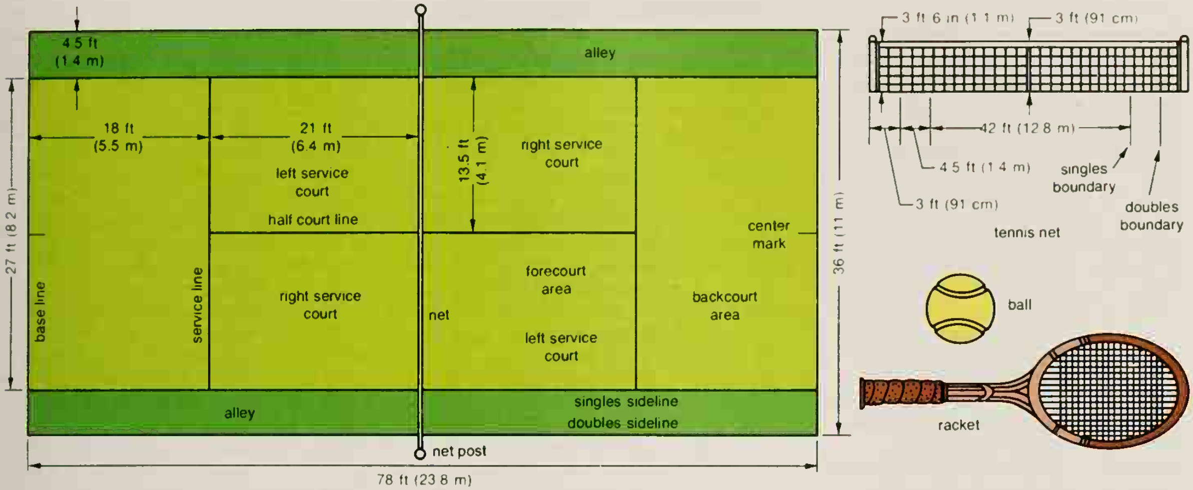
The TVA's achievements are not easy to assess. It has certainly helped to transform agricultural practice in the area, and it has contributed greatly to flood control and the prevention of soil erosion. It has also aided Southern industrial growth. It has not, however, proved a model of regional development or a yardstick against which other utilities can be measured, as had once been hoped.

Tennessee walking horse see HORSE

Tenniel, Sir John [ten'-ee-uhl] The British artist and cartoonist Sir John Tenniel, b. Feb. 28, 1820, d. Feb. 25, 1914, is best known as the illustrator of Lewis Carroll's ALICE'S ADVENTURES IN WONDERLAND (1865) and *Through the Looking-Glass* (1872). Educated at the Royal Academy schools, he won a competition in 1845 for a mural at the House of Lords in the Palace of Westminster. In 1850, Tenniel joined the staff of the satirical periodical *Punch*. From 1851 until his retirement in 1901, he produced more than 2,000 drawings, caricatures, and political cartoons for that magazine, including the noted "Dropping the Pilot" (1890), about the dismissal of Otto von Bismarck. Tenniel illustrated numerous books, including *Aesop's Fables* (1848) and Richard Harris Barnham's *Ingoldsby Legends* (1864). Tenniel was knighted in 1893.

Alice's encounter with Tweedledum and Tweedledee is one of the illustrations Sir John Tenniel created for the first edition of Lewis Carroll's Through the Looking-Glass *(1872).*

tennis Tennis, also known as lawn tennis, is probably the most popular and universal of the racquet-and-ball sports. The basic object of the game is to use a racquet to hit the ball over a net but within the boundaries of the opposite half of the court. The game is played competitively or informally by millions of people worldwide. With the proliferation of indoor courts, most notably in the United States, the sport is played all year round. Organized U.S. competition is governed by the United States Tennis Association (USTA), and international matches are regulated by the International Tennis Federation (ITF). Variations include BADMINTON, PADDLE TENNIS, PLATFORM TENNIS, RACQUETBALL, SQUASH, and TABLE TENNIS.



Tennis is a sport played on a 78-by-36-ft (23.8-by-11-m) court bisected by a net 3.5 ft (1.1 m) high (top right). *Players hit a ball back and forth across the net with a strung racket* (bottom right). *Points are scored when a player fails to return the ball over the net or hits it out of bounds.*

History

The word *tennis* is derived from the Old French name for the game, *tenetz.* A tennislike game was played in late-13th-century France, primarily in Paris among the upper classes. Some authorities believe that the French learned about the game from the Italians and the Greeks, who were known to play a similar game during that period. The French game was called *jeu de paume,* "game of the palm," because the players used the palms of their hands to strike the ball. Later, racquets were used to allow the players greater reach. Approximately 100 years later, the British aristocracy started to play the game. The game was played indoors with a cumbersome racquet and a confusing set of rules. This game, somewhat similar to badminton, is still played today and is called court tennis in the United States and real tennis in Great Britain.

It was not until 1873, however, that Maj. Walter Clopton Wingfield, making use of his knowledge of real tennis, invented lawn tennis. In December 1873, Wingfield announced a set of rules for his new racquet game. The game was played outdoors on grass on an hourglass-shaped court, and the net was much higher than it is today.

Mary Ewing Outerbridge, an American, was in Bermuda in 1874 and noticed some British men playing the game. She took tennis equipment home with her and introduced the sport to friends in Staten Island, N.Y. Tennis was soon disseminated to other parts of the United States.

The first U.S. tennis championship was held in 1881 at the Newport Casino in Newport, R.I. The U.S. championship moved to Forest Hills, N.Y., and was held there from 1915 to 1977, with the exception of 1921–23. In 1978 the event moved to the U.S. Tennis Association National Tennis Center in Flushing Meadow, N.Y.

International interest in tennis paralleled the interest shown within the United States. Wimbledon, the first of the major international championships, was played in 1877. The French championship was first played in 1891, and the Australian championship in 1905. Along with the U.S. championship these tournaments soon became known as the Big Four, and they constitute the so-called Grand Slam of tennis. National teams have been competing for the Davis Cup, symbol of international tennis supremacy, since 1900.

The advent of "open" tennis in 1968, in which amateurs and professionals play against each other in organized competition, greatly stimulated interest in tennis at all levels. Professionals have come to dominate the sport.

Martina Navratilova leaps for a forehand volley at the 1984 Wimbledon tournament, whose singles title she won for the third consecutive year. After her 1990 victory, she had won nine times overall (1978–79, 1982–87, 1990). Navratilova's phenomenal singles and doubles performances in the 1980s assure her place as one of the greatest women players of all time.

BRITISH (WIMBLEDON) CHAMPIONS

MEN'S SINGLES

1877	Spencer W. Gore (U.K.)
1878	P. Frank Hadow (U.K.)
1879–80	J. T. Hartley (U.K.)
1881–86	William Renshaw (U.K.)
1887	Herbert F. Lawford (U.K.)
1888	Ernest Renshaw (U.K.)
1889	William Renshaw (U.K.)
1890	Willoughby J. Hamilton (U.K.)
1891–92	Wilfred Baddeley (U.K.)
1893–94	Joshua L. Pim (U.K.)
1895	Wilfred Baddeley (U.K.)
1896	Harold S. Mahony (U.K.)
1897–1900	Reginald Doherty (U.K.)
1901	Arthur W. Gore (U.K.)
1902–06	Hugh L. Doherty (U.K.)
1907	Norman Brookes (Austr.)
1908–09	Arthur W. Gore (U.K.)
1910–13	Anthony F. Wilding (N.Z.)
1914	Norman Brookes (Austr.)
1915–18	No competition
1919	Gerald Patterson (Austr.)
1920–21	William T. Tilden (U.S.)
1922	Gerald Patterson (Austr.)
1923	William Johnston (U.S.)
1924	Jean Borotra (Fr.)
1925	René Lacoste (Fr.)
1926	Jean Borotra (Fr.)
1927	Henri Cochet (Fr.)
1928	René Lacoste (Fr.)
1929	Henri Cochet (Fr.)
1930	William T. Tilden (U.S.)
1931	Sidney B. Wood (U.S.)
1932	Ellsworth Vines (U.S.)
1933	John Crawford (Austr.)
1934–36	Fred J. Perry (U.K.)
1937–38	J. Donald Budge (U.S.)
1939	Robert L. Riggs (U.S.)
1940–45	No competition
1946	Yvon Petra (Fr.)
1947	John A. Kramer (U.S.)
1948	Robert Falkenburg (U.S.)
1949	Fred R. Schroeder (U.S.)
1950	J. Edward Patty (U.S.)
1951	Richard Savitt (U.S.)
1952	Frank Sedgman (Austr.)
1953	E. Victor Seixas (U.S.)
1954	Jaroslav Drobny (Czech.)
1955	Tony Trabert (U.S.)
1956–57	Lewis Hoad (Austr.)
1958	Ashley Cooper (Austr.)
1959	Alejandro Olmedo (Peru)
1960	Neale Frazer (Austr.)
1961–62	Rodney Laver (Austr.)
1963	Charles McKinley (U.S.)
1964–65	Roy Emerson (Austr.)
1966	Manuel Santana (Spain)
1967	John Newcombe (Austr.)
1968–69	Rodney Laver (Austr.)
1970–71	John Newcombe (Austr.)
1972	Stanley Smith (U.S.)
1973	Jan Kodes (Czech.)
1974	James Connors (U.S.)
1975	Arthur Ashe (U.S.)
1976–80	Björn Borg (Sweden)
1981	John McEnroe (U.S.)
1982	James Connors (U.S.)
1983–84	John McEnroe (U.S.)
1985–86	Boris Becker (W.Ger.)
1987	Pat Cash (Austr.)
1988	Stefan Edberg (Sweden)
1989	Boris Becker (W.Ger.)
1990	Stefan Edberg (Sweden)
1991	Michael Stich (Ger.)
1992	Andre Agassi (U.S.)

WOMEN'S SINGLES

1884–85	Maud Watson (U.K.)
1886	Blanche Bingley (U.K.)
1887–88	Lottie Dod (U.K.)
1889	Blanche Bingley Hillyard (U.K.)
1890	L. Rice (U.K.)
1891–93	Lottie Dod (U.K.)
1894	Blanche Bingley Hillyard (U.K.)
1895–96	Charlotte Cooper (U.K.)
1897	Blanche Bingley Hillyard (U.K.)
1898	Charlotte Cooper (U.K.)
1899–1900	Blanche Bingley Hillyard (U.K.)
1901	Charlotte Cooper Sterry (U.K.)
1902	M. E. Robb (U.K.)
1903–04	Dorothy K. Douglass (U.K.)
1905	May G. Sutton (U.S.)
1906	Dorothy K. Douglass (U.K.)
1907	May G. Sutton (U.S.)
1908	Charlotte Cooper Sterry (U.K.)
1909	Dorothea P. Boothby (U.K.)
1910–11	Dorothy D. Chambers (U.K.)
1912	Ethel W. Larcombe (U.K.)
1913–14	Dorothy D. Chambers (U.K.)
1915–18	No competition
1919–23	Suzanne Lenglen (Fr.)
1924	Kathleen McKane (U.K.)
1925	Suzanne Lenglen (Fr.)
1926	Kathleen McKane Godfree (U.K.)
1927–29	Helen N. Wills (U.S.)
1930	Helen Wills Moody (U.S.)
1931	Cecil Aussem (Ger.)
1932–33	Helen Wills Moody (U.S.)
1934	Dorothy E. Round (U.K.)
1935	Helen Wills Moody (U.S.)
1936	Helen H. Jacobs (U.S.)
1937	Dorothy E. Round (U.K.)
1938	Helen Wills Moody (U.S.)
1939	Alice Marble (U.S.)
1940–45	No competition
1946	Pauline Betz (U.S.)
1947	Margaret Osborne (U.S.)
1948–50	Louise Brough (U.S.)
1951	Doris J. Hart (U.S.)
1952–54	Maureen Connolly (U.S.)
1955	Louise Brough (U.S.)
1956	Shirley J. Fry (U.S.)
1957–58	Althea Gibson (U.S.)
1959–60	Maria Bueno (Brazil)
1961	Angela Mortimer (U.K.)
1962	Karen H. Susman (U.S.)
1963	Margaret Smith (Austr.)
1964	Maria Bueno (Brazil)
1965	Margaret Smith (Austr.)
1966–68	Billie Jean King (U.S.)
1969	Ann Haydon Jones (U.K.)
1970	Margaret Smith Court (Austr.)
1971	Evonne Goolagong (Austr.)
1972–73	Billie Jean King (U.S.)
1974	Chris Evert (U.S.)
1975	Billie Jean King (U.S.)
1976	Chris Evert (U.S.)
1977	Virginia Wade (U.K.)
1978–79	Martina Navratilova (Czech.)
1980	Evonne Goolagong (Austr.)
1981	Chris Evert Lloyd (U.S.)
1982–87	Martina Navratilova (U.S.)
1988–89	Steffi Graf (W.Ger.)
1990	Martina Navratilova (U.S.)
1991–92	Steffi Graf (Ger.)

Equipment and Court

The standard tennis court is 78 ft (23.8 m) long. For singles play, the court is 27 ft (8.2 m) wide; for doubles, the width is extended to 36 ft (11 m). A net 3.5 ft (1.1 m) high at the ends and 3 ft (91 cm) high at the center divides the length of the court in half. Toward the backline, or baseline, and 21 ft (6.4 m) from the net, is the service line. The service line, the net, and the singles sidelines form the service area. The area is divided by a center line to form two service courts, each 13.5 ft (4.1 m) wide.

The ball, though traditionally white, is now high-visibility yellow and is made of hollow rubber with a wool and artificial fiber covering. For informal play, racquets may be of almost any size, weight, shape, or construction. Most racquets are 27 in (68.6 cm) long with faces 9 in (22.9 cm) wide; weight is usually 13–15 oz (368.5–425.2 g). Racquet handles are covered with leather, cloth, or plastic to ensure a good grip. Strings may be made of nylon, gut, or plastic. Although wood used to be the most frequently used frame material, aluminum, boron, graphite, and combinations thereof now dominate.

U.S. OPEN CHAMPIONS

MEN'S SINGLES

1881–87	Richard D. Sears (U.S.)
1888–89	Henry W. Slocum, Jr. (U.S.)
1890–92	Oliver S. Campbell (U.S.)
1893–94	Robert D. Wrenn (U.S.)
1895	Fred H. Hovey (U.S.)
1896–97	Robert D. Wrenn (U.S.)
1898–1900	Malcolm D. Whitman (U.S.)
1901–02	William A. Larned (U.S.)
1903	Hugh L. Doherty (U.K.)
1904	Holcombe Ward (U.S.)
1905	Beals C. Wright (U.S.)
1906	William J. Clothier (U.S.)
1907–11	William A. Larned (U.S.)
1912–13	Maurice E. McLoughlin (U.S.)
1914	R. Norris Williams (U.S.)
1915	William M. Johnston (U.S.)
1916	R. Norris Williams (U.S.)
1917–18	R. Lindley Murray (U.S.)
1919	William M. Johnston (U.S.)
1920–25	William T. Tilden (U.S.)
1926–27	René Lacoste (Fr.)
1928	Henri Cochet (Fr.)
1929	William T. Tilden (U.S.)
1930	John H. Doeg (U.S.)
1931–32	H. Ellsworth Vines, Jr. (U.S.)
1933–34	Frederick J. Perry (U.K.)
1935	Wilmer L. Allison (U.S.)
1936	Frederick J. Perry (U.K.)
1937–38	J. Donald Budge (U.S.)
1939	Robert L. Riggs (U.S.)
1940	W. Donald McNeill (U.S.)
1941	Robert L. Riggs (U.S.)
1942	Frederick R. Schroeder (U.S.)
1943	Joseph E. Hunt (U.S.)
1944–45	Frank A. Parker (U.S.)
1946–47	John A. Kramer (U.S.)
1948–49	Richard A. Gonzales (U.S.)
1950	Arthur D. Larsen (U.S.)
1951–52	Frank Sedgman (Austr.)
1953	Tony Trabert (U.S.)
1954	E. Victor Seixas, Jr. (U.S.)
1955	Tony Trabert (U.S.)
1956	Kenneth Rosewall (Austr.)
1957	Malcolm Anderson (Austr.)
1958	Ashley Cooper (Austr.)
1959–60	Neale Fraser (Austr.)
1961	Roy Emerson (Austr.)
1962	Rodney Laver (Austr.)
1963	Rafael Osuna (Mex.)
1964	Roy Emerson (Austr.)
1965	Manuel Santana (Spain)
1966	Fred S. Stolle (Austr.)
1967	John Newcombe (Austr.)
1968	Arthur Ashe (U.S.)
1969	Rodney Laver (Austr.)
1970	Kenneth Rosewall (Austr.)
1971	Stanley Smith (U.S.)
1972	Ilie Nastase (Rom.)
1973	John Newcombe (Austr.)
1974	James Connors (U.S.)
1975	Manuel Orantes (Spain)
1976	James Connors (U.S.)
1977	Guillermo Vilas (Argent.)
1978	James Connors (U.S.)
1979–81	John McEnroe (U.S.)
1982–83	James Connors (U.S.)
1984	John McEnroe (U.S.)
1985–87	Ivan Lendl (Czech.)
1988	Mats Wilander (Sweden)
1989	Boris Becker (W.Ger.)
1990	Pete Sampras (U.S.)
1991–92	Stefan Edberg (Sweden)

WOMEN'S SINGLES

1887	Ellen F. Hansell (U.S.)
1888–89	Bertha L. Townsend (U.S.)
1890	Ellen C. Roosevelt (U.S.)
1891–92	Mabel E. Cahill (U.S.)
1893	Aline M. Terry (U.S.)
1894	Helen R. Helwig (U.S.)
1895	Juliette P. Atkinson (U.S.)
1896	Elisabeth H. Moore (U.S.)
1897–98	Juliette P. Atkinson (U.S.)
1899	Marion Jones (U.S.)
1900	Myrtle McAteer (U.S.)
1901	Elisabeth H. Moore (U.S.)
1902	Marion Jones (U.S.)
1903	Elisabeth H. Moore (U.S.)
1904	May G. Sutton (U.S.)
1905	Elisabeth H. Moore (U.S.)
1906	Helen Homans (U.S.)
1907	Evelyn Sears (U.S.)
1908	Maud Bargar-Wallach (U.S.)
1909–11	Hazel V. Hotchkiss (U.S.)
1912–14	Mary K. Browne (U.S.)
1915–18	Molla Bjurstedt (U.S.)
1919	Hazel H. Wightman (U.S.)
1920–22	Molla B. Mallory (U.S.)
1923–25	Helen N. Wills (U.S.)
1926	Molla B. Mallory (U.S.)
1927–29	Helen N. Wills (U.S.)
1930	Betty Nuthall (U.K.)
1931	Helen Wills Moody (U.S.)
1932–35	Helen H. Jacobs (U.S.)
1936	Alice Marble (U.S.)
1937	Anita Lizana (Chile)
1938–40	Alice Marble (U.S.)
1941	Sarah Palfrey Cooke (U.S.)
1942–44	Pauline M. Betz (U.S.)
1945	Sarah Palfrey Cooke (U.S.)
1946	Pauline M. Betz (U.S.)
1947	Louise Brough (U.S.)
1948–50	Margaret O. du Pont (U.S.)
1951–53	Maureen Connolly (U.S.)
1954–55	Doris Hart (U.S.)
1956	Shirley J. Fry (U.S.)
1957–58	Althea Gibson (U.S.)
1959	Maria Bueno (Brazil)
1960–61	Darlene Hard (U.S.)
1962	Margaret Smith (Austr.)
1963–64	Maria Bueno (Brazil)
1965	Margaret Smith (Austr.)
1966	Maria Bueno (Brazil)
1967	Billie Jean King (U.S.)
1968	Virginia Wade (U.K.)
1969–70	Margaret Smith Court (Austr.)
1971–72	Billie Jean King (U.S.)
1973	Margaret Smith Court (Austr.)
1974	Billie Jean King (U.S.)
1975–78	Chris Evert (U.S.)
1979	Tracy Austin (U.S.)
1980	Chris Evert Lloyd (U.S.)
1981	Tracy Austin (U.S.)
1982	Chris Evert Lloyd (U.S.)
1983–84	Martina Navratilova (U.S.)
1985	Hana Mandlikova (Czech.)
1986–87	Martina Navratilova (U.S.)
1988–89	Steffi Graf (W.Ger.)
1990	Gabriela Sabatini (Argent.)
1991–92	Monica Seles (Czech.)

Play

Serve is determined by flipping a racquet. Players serve for one complete game. The serve used most often is the overhead serve. This is accomplished by tossing the ball into the air and, with a throwing motion of the racquet hand, hitting the ball with the face of the racquet. The server must stand behind the baseline and on the first serve of the game must stay to the right of the center of the court. A proper serve will pass over the net into the service court diagonally opposite. On each serve the server has two opportunities to make a legal serve. Missing both serves results in a "double fault" and the loss of a point. After the scoring of the first point in any individual game, the server moves to the left of the center of the court and serves to the other service area. After each point this change of service court is repeated. In doubles, as in singles, one person serves for the entire game, but the serve is directed first to one member of the opposing team and then to the other. Should a serve touch the net and then fall into the appropriate service court, the ball is termed a *let*, and the server is permitted to try that serve again. A foot fault is called if the server's foot touches or crosses the baseline before the ball is struck, resulting in the loss of a point.

After the serve the players attempt to hit the ball back and forth over the net until one player commits an error or is unable to return the ball. A point is lost when a player fails to hit the ball before the second bounce, hits the ball into the net, hits the ball out of bounds, touches the net with the racquet or with the body, hits the ball twice, is hit by the ball, or hits the ball before it crosses the net. Players switch court sides after the first game and after each odd-numbered game.

Scoring

A unique system is used to keep score in tennis. Games, which consist of four points, are scored as follows: "love" indicates no score, "15" indicates one point scored, "30" indicates two points, "40" indicates three points, and "game" indicates four points. If a tie of 40-all occurs, the situation is called *deuce*, and to win one player must score two points more than the opponent in that game.

Tennis matches are usually won by winning the best out of three or the best out of five "sets." In most cases, a set is awarded to the player who wins six games before the opponent has won more than four. Formerly, if a set was tied at five games apiece, the method used to resolve it was similar to the deuce arrangement in the individual games. Thus, set scores of 7–5, 10–8, or 15–13 were not uncommon. An innovation called a tie breaker is now generally used to terminate quickly what might turn into an extended set. Whenever a set is tied at six games apiece, the tie breaker is invoked. There are two tie-breaking systems. In one the first player to score five out of nine individual points wins the set; in the other the first player to score seven individual points wins, provided the margin of victory is two points or more.

Tennyson, Alfred, Lord [ten'-i-suhn] The preeminent English poet of his time, Alfred, Lord Tennyson, b. Somersby, Lincolnshire, Aug. 6, 1809, d. Oct. 6, 1892, began writing poetry as a child and, with two of his brothers, Frederick and Charles, published a volume of poems before he entered Cambridge University in 1827. There he formed a close friendship with Arthur Hallam, whose death (1833), combined with the poor reception of his own *Poems* (1832), plunged Tennyson into a decade-long silence during which he wrote much but published little. Reemerging as a mature poet in 1842 with a two-volume collection of new and revised poems that included "Locksley Hall," "Ulysses," "Morte d'Arthur," "Mariana," and "The Lady of Shalott," he then established his eminence with *In Memoriam* (1850), his elegy for Hallam. Later the same year he was named poet laureate, and in 1859 he began publishing his version of a national epic in *Idylls of the King*, retellings of Arthurian legends.

Alfred, Lord Tennyson epitomized the moral and philosophical concerns of the Victorian age in his work. His appointment as England's poet laureate followed the publication of In Memoriam *(1850), one of the finest elegies in English literature. (National Portrait Gallery, London.)*

As laureate, Tennyson composed a number of poems on national occasions, notably The CHARGE OF THE LIGHT BRIGADE. In the exquisite lyrics of "Maud" (1855), he used as the nucleus for an extended psychological monodrama some verses he had written almost 20 years before. After the success of *Enoch Arden and Other Poems* (1864), which sold 40,000 copies, and by the time the immensely popular *Idylls of the King* had reached completion (1885), Tennyson had become both a celebrity and a sage. He accepted a peerage, becoming a baron, and a seat in the House of Lords in 1884.

One of Tennyson's important concerns was to involve his poetry in the public life of the time without sacrificing personal feeling and perception. During the last decade of his life he complemented his analyses of Greek figures—*Tiresias, and Other Poems* (1885) and *The Death of Oenone* (1892)—with reflections on death and the meaning of life—*Locksley Hall Sixty Years After* (1886) and "Crossing the Bar" (1889)—and with historical plays such as the highly successful *Becket* (1884).

Tenochtitlán [tay-nohch-teet-lahn'] The Aztec capital of Tenochtitlán (at modern Mexico City) was founded in AD 1345 (or 1325, according to some chronicles) on a muddy island in the lake that at that time filled the Basin of Mexico. A second group of Aztec settled the nearby island of Tlatelolco in 1358. Both sites began as small collections of reed huts but, with the growth of Aztec power, developed into cities, eventually fusing into a single conurbation.

By 1519, the year the Spaniards arrived, Tenochtitlán-Tlatelolco had a population of more than 150,000. It was laid out on a grid plan and covered more than 12 km^2 (4.6 mi^2), much of this consisting of reclaimed swampland that formed a zone of fertile garden plots around the edge of the city. At the center of Tenochtitlán was a large walled precinct containing the main temples, schools and priests' quarters, a court for the ritual ball game, a wooden rack holding the skulls of sacrificial victims, and many commemorative sculptures. Just outside the precinct walls were the palaces of MONTEZUMA II and earlier rulers. A 16-km (10-mi) dike sealed off part of the lake and controlled flooding, so that Tenochtitlán, like a Mexican Venice, stood on an island in an artificial lagoon. Causeways linked the island to the lakeshore, and canals reached to all parts of the city.

Between 1519 and 1521, Tenochtitlán was besieged by the Spaniards under Hernán CORTÉS. To create space for their cavalry to maneuver, the invaders pulled down most of the city's buildings, later constructing colonial Mexico City on the same spot. Only a few mutilated Aztec buildings can be seen today.

tenor The highest adult male voice, excepting falsetto and COUNTERTENOR, is the tenor, with a range roughly from C below middle C upward for about two octaves. The name is derived from the lowest part sung in 12th-century polyphony, where it was the responsibility of the tenor to hold (*tenere*) the cantus firmus in lengthened notes. As choral voices divided into tenor and bass, the term took on its present meaning. The distinction between lyric and dramatic tenors is one of tone quality, the two being akin to their soprano counterparts. A heldentenor, one with exceptional qualities of endurance, is required for certain roles in the German romantic opera literature, particularly Wagnerian roles.

tenrec [ten'-rek] The 20 or more species of tenrecs are a group of essentially primitive, earthworm- and insect-eating mammals indigenous to Madagascar that form the family Tenrecidae. Nocturnal animals with poor vision, the sharply muzzled tenrecs grow to about 37 cm (15 in). They have compact bodies and short legs and nest in burrows. Extremely prolific, tenrecs bear litters of up to 25; the female has up to 12 pairs of mammary glands. The spring tenrec, or Madagascar hedgehog, erects its stiff, spiny hairs and curls into a ball when threatened, thus resembling a true hedgehog. Some tenrecs hibernate through the hot, dry season.

The tenrec is a small mammal native to Madagascar. One of the largest of the insectivores, it uses its snout to dig for worms and insects.

Tenskwatawa see SHAWNEE PROPHET

tent caterpillar Tent caterpillar is the common name for the larval, or caterpillar, stage of certain moths (genus *Malacosoma*) of the family Lasiocampidae. The larvae are economically important because they often seriously damage tree foliage. Adult females lay egg clusters on tree twigs. The hatched caterpillars construct a tentlike shelter of silk to which they return at night after feeding on foliage. Mature larvae are about 7.5 cm (3 in) long, with bright spots or streaks on a dark, hairy body.

10th Amendment see BILL OF RIGHTS; CONSTITUTION OF THE UNITED STATES; STATE RIGHTS

Tenure of Office Act The Tenure of Office Act, passed by the U.S. Congress over President Andrew JOHNSON's veto on Mar. 2, 1867, stipulated that a president could not, without Senate approval, remove any officeholder appointed with the Senate's consent.

The act was adopted in part to keep in office appointees sympathetic to Radical RECONSTRUCTION, particularly Secretary of War Edwin M. STANTON. Johnson defied the act with his dismissal of Stanton on Feb. 21, 1868, spurring the House of Representatives to impeach the chief executive three days later. The act was amended in 1869, repealed in 1887, and declared to have been unconstitutional by the U.S. Supreme Court in 1926.

Teotihuacán [tay-oh-tee-wah-kahn'] Teotihuacán, located just northeast of Mexico City, dominated central Mexico and much of the rest of MESOAMERICA during the early part of the 1st millennium AD. By AD 100 it had become a large center with a population of 50,000 or more. Known for its enormous expanse of monumental architecture, Teotihuacán was the first true city in Mesoamerica and one of its largest. At its peak (AD *c.*600) it housed more than 100,000 people and was the capital of a powerful state or empire. Its direct political influence reached EL TAJÍN and a number of other Gulf Coast centers. KAMINALJUYÚ, in the highlands of Guatemala, was another Teotihuacán outpost and a center for economic interaction with the MAYA.

Farmers formed the backbone of Teotihuacán society, and political officials, priests, merchants, and military leaders made up the elite. Craft specialists—stoneworkers, potters, sculptors, painters, and the like—lived in their own neighborhoods, as did foreign residents. After 600, Teotihuacán influence began to shrink. By 650 it had lost its dominance, and shortly thereafter it was looted and burned. A small population lived on in its valley. The AZTEC believed that the ruins had been built by the gods, and they sometimes made pilgrimages there.

At its peak Teotihuacán covered about 20 km^2 (8 mi^2), with temples, palaces, markets, reservoirs, and more than 2,000 multiroomed apartment compounds. The streets

The Pyramid of the Sun at Teotihuacán, one of the earliest commercial and religious centers of pre-Columbian central Mexico, is famed for its monumental size and impressive architecture.

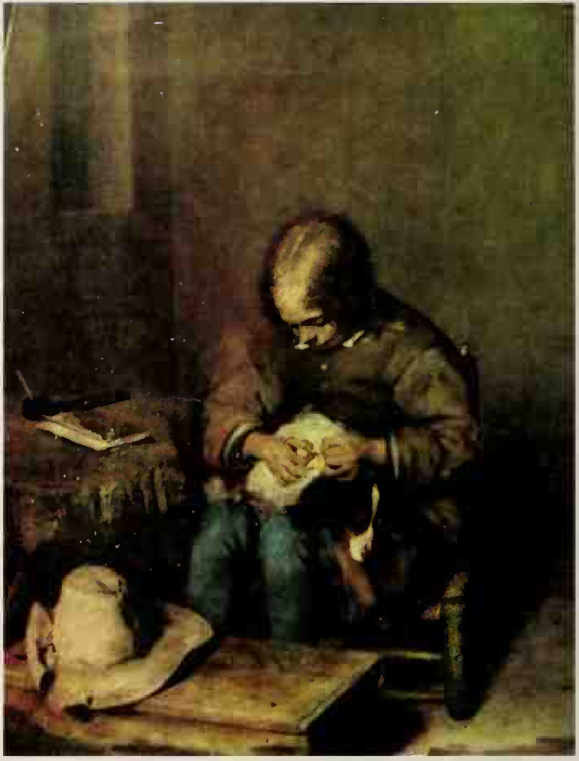
and buildings were laid out on a grid plan, and even streams within the city were channeled to conform to the pattern. At the intersection of the principal avenues were the main temple-palace complex (the Citadel) and the chief marketplace (the Great Compound). The so-called Street of the Dead, lined with palaces and temples, ran north past the enormous Pyramid of the Sun to the slightly smaller Pyramid of the Moon. Polychrome murals adorned the walls of major buildings, many depicting gods later worshiped by the Aztec.

tepee [tee'-pee] *Tepee*, or *tipi*, is a Sioux Indian word for a portable dwelling composed of a framework of long wooden poles pointed together and fastened at the top and spread out on the ground in a circle at the butt ends, with a tent cover of skins being drawn around the frame and fastened on the ground with pegs or weighted with stones. Most tepees have a central fireplace over which a smoke-hole is formed by drawing the cover apart at the apex. A tepee may be as large as 4.5 m (15 ft) high and 7 to 9 m (23 to 30 ft) in diameter and can be assembled or disassembled by an expert within a few minutes. Tepees traditionally were used principally by the bison hunters of the Great Plains of North America, notably the BLACKFOOT, CHEYENNE, CROW, and SIOUX.

tequila [tuh-kee'-luh] Tequila is an alcoholic beverage made of the fermented and distilled sap taken from the base of AGAVE plants, especially those cultivated in the Mexican state of Jalisco. The liquor, which is usually distilled twice to achieve the desired purity and potency, is colorless and is not aged. (A few tequilas, however, may be put up to age in oak vats, and they take on a pale yellow color.) Alcohol content ranges from 80 to 100 proof (40% to 50%). Mescal and pulque, both similar to tequila but heavier in flavor, are distilled from sap taken from the roots, stalk, and leaves of wild agave plants.

Ter Borch, Gerard [tur-bork'] With Jan Vermeer and Pieter de Hooch, Gerard Ter Borch, b. 1617, d. Dec. 8, 1681, was one of the principal creators of the high genre style of the 1650s and '60s that was the climax of the long tradition of Dutch realism. Ter Borch revealed a world in which the writing of a letter, the playing of a guitar, or the peeling of an apple could be a major event. Throughout his career he was a sensitive portrait painter who portrayed his well-dressed subjects with a vulnerability unusual in commissioned portraits.

He did the official painting (1648; National Gallery, London) of the signatories of the Treaty of Westphalia, which ended the Thirty Years' War and confirmed the independence of the Netherlands from Spain. In the 1650s and '60s, Ter Borch did his greatest work, paintings of women in boudoirs looking in the mirror, arranging their hair, or reading love letters. His brilliant painting of satins, oriental carpets, and jewels was partly a response to the extraordinary affluence in Dutch society after 1650. Above all, his subjects seem to live in a world that is gentle, safe, and civilized.



In A Boy Ridding His Dog of Fleas *(c. 1665), a typically charming genre scene by Gerard Ter Borch, the boy has cast aside his lesson book to attend to the dog. (Bayerische Staatsgemäldesammlungen, Munich.)*

terbium [tur'-bee-uhm] Terbium is a chemical element, a very rare silver gray metal of the LANTHANIDE SERIES of the PERIODIC TABLE. Its symbol is Tb, its atomic number is 65, and its atomic weight is 158.9254. Terbium was discovered in 1843 by C. G. Mosander; it was first extracted in fairly pure form by G. Urbain in 1905. It is studied mainly because of its complex magnetic behavior.

Terbrugghen, Hendrick [tair-brug'-huhn] Hendrick Terbrugghen, b. 1588, d. Nov. 1, 1629, was the most influential of the Utrecht school of Dutch painters who followed the example of Michelangelo Merisi da Caravaggio. His earliest-dated extant painting is *Christ Mocked* (1620; Statens Museum for Kunst, Copenhagen). The *Calling of Saint Matthew* (1621; Centraal Museum, Utrecht) relies for inspiration on Caravaggio's picture of the same subject in San Luigi dei Francesi, Rome. Terbrugghen also painted numerous half-length drinking or music-making figures derived from the early work of Caravaggio and his followers, such as Bartolomeo Manfredi. In a later work, *Saint Sebastian Tended by Saint Irene and Her Maid* (1625; Allen Memorial Art Museum, Oberlin, Ohio), there is a tender solemnity to the figures and a luminous yellow lighting that was later to influence Jan Vermeer.

Terence [tair'-uhns] The Roman playwright Terence, the anglicized name of Publius Terentius Afer, *c.*185–*c.*159 BC, was born in Carthage and came to Rome as the young slave of a senator who gave him a good education and set him free. SCIPIO AFRICANUS MINOR became his patron, encouraging him to adapt Greek plays of the so-called New Comedy—especially the plays of MENANDER—for the Roman stage.

Between 166 and 160 BC, Terence had six plays produced: *Andria* (The Girl from Andros), *Heautontimorumenos* (The Self-Torturer), *Eunuchus* (The Eunuch), *Phormio* (the name of the principal character, an ingratiating parasite), *Adelphi* (The Brothers), and *Hecyra* (The Mother-in-Law). More refined but less original than Rome's other preeminent comic dramatist, PLAUTUS, Terence nevertheless excelled at suspenseful plots and exploited the stock characters that have become staples of Western romantic comedy.

Teresa, Mother [tuh-ray'-suh] Internationally respected for her work to relieve the sufferings of the poor and dying, Mother Teresa of Calcutta, b. Aug. 27, 1910, was awarded the 1979 Nobel Peace Prize. An Albanian originally named Agnes Gonxha Bejaxhiu, she entered the order of the Sisters of Our Lady of Loreto at the age of 18. She taught in the order's school in Calcutta until 1946, when she experienced what she described as a "call within a call" to aid the desperately poor of India in a way that required she leave her convent. In 1950, Mother Teresa received official approval for a congregation of sisters, the Missionaries of Charity, whose members are dedicated to serving the poorest of the poor.

Mother Teresa, winner of the 1979 Nobel Peace Prize, dedicated her life to the service of Calcutta's homeless poor and founded (1950) a Roman Catholic order to expand her work. Her compassionate service includes the establishment of leper colonies and homes for the dying.

Teresa of Ávila, Saint [ah'-vee-lah] Saint Teresa of Ávila, b. Mar. 28, 1515, d. Oct. 4, 1582, was a Spanish Carmelite and mystic who was declared a doctor of the church in 1970. The daughter of a noble Spanish family, she was originally named Teresa de Cespeda y Ahumada. In 1535 she entered the Carmelite monastery of the Incarnation at Ávila, where the nuns observed the rules of the order in a relaxed ("mitigated") way. After a serious illness and a prolonged period of spiritual apathy, Teresa experienced (1555) a spiritual reawakening that convinced her of the need for strict observance of the austere Carmelite rule. Despite strong opposition, she succeeded (1562) in opening the Convent of Saint Joseph in Ávila, the first of the reformed Carmelite houses. Until her death she led the way in reforming both the male and female branches of the Carmelite order. Along with Saint John of the Cross, she is considered the founder of the Discalced ("shoeless") Carmelites.

Besides her activity in directing the reform of her order, which involved extensive travel and communication with nobility and church officials, Teresa wrote many works, among which are some of the greatest classics of mystical literature. Feast day: Oct. 15.

Tereshkova, Valentina Vladimirovna Nikolayeva [te-ruhsh-koh'-vuh] The Soviet cosmonaut Valentina Vladimirovna Nikolayeva Tereshkova, b. Mar. 6, 1937, was the first woman in space. She was a textile-factory assembly worker and amateur parachutist at the time she was recruited (1961) into a special cosmonaut program under the direction of Soviet premier Nikita Khrushchev. Tereshkova received a commission in the Soviet Air Force and took part in an 18-month orientation program before being selected as the prime pilot for the flight of *Vostok 6*. She was launched on June 16, 1963, and spent nearly 3 days in space at the same time as cosmonaut Valery Bykovsky in *Vostok 5* (the spaceships were in separate orbits).

In 1963, Tereshkova married cosmonaut Andrian Nikolayev. Tereshkova later served on political organizations, including committees connected with the international women's movement, and was elected to the Soviet parliament as a delegate from her home town of Yaroslavl.

Terman, Lewis [tur'-muhn] The pioneer of intelligence tests in the United States, Lewis Madison Terman, b. Johnson County, Ind., Jan. 15, 1877, d. Dec. 21, 1956, was an educational psychologist known for his long-term study of highly intelligent individuals. He joined the faculty of Stanford University in 1910 and worked there until his retirement (1942). In 1916 he adapted the Binet intelligence test (see STANFORD-BINET TEST) and introduced the term *intelligence quotient* (IQ). The Stanford-Binet scale and its subsequent revisions by Terman and Maud A. Merrill became the most widely used of all mental tests for children. Terman was largely responsible for producing Alpha and Beta group tests for U.S. Army recruits in 1917. In the 1920s he began his studies of approximately 1,500 of the brightest children in California, with IQs of 135 and up, and traced their careers in four volumes of *Genetic Studies of Genius* (1925–59), documenting their high accomplishments and generally superior social adjustment.

See also: INTELLIGENCE.

termite Termites (order Isoptera) are mainly tropical and subtropical insects, comprising nearly 1,800 species in about 200 genera. Common to warm and humid climates, they are also found in North America and southern Europe. Termites evolved from roachlike ancestors. They are the only insects other than bees, ants, and wasps (order Hymenoptera) to form true societies. Known primarily for their destruction of wooden structures, termites can also be agricultural pests.

Feeding Habits. All termites are herbivorous, and many feed on decaying wood. Termites are able to digest cellulose, a carbohydrate found in plants, because of bacteria in their intestines. Some species also have symbiotic protozoans in the gut. Many subterranean or mound-building species cultivate fungi that help to break down plant material that has been incorporated into "fungus gardens."

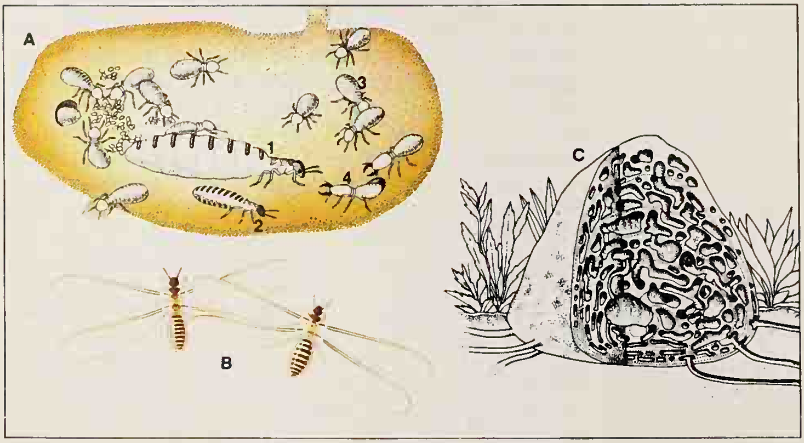
Life Cycle. In many ways the life cycle and habits of termites are similar to those of ants. (This is the reason termites are also referred to as "white ants," although termites and ants differ in a number of important aspects.) The individuals of the society are divided into castes: the primary reproductives (king and queen), the supplementary reproductives, the workers, and the soldiers. The king and queen stay together after mating. Commonly the queen's ovaries grow enormously so that her abdomen becomes greatly distended, and she is able to lay eggs continuously. The eggs hatch into young brood, which resemble small workers and, in more primitive kinds of termites, behave like them. In other species the young are fairly helpless and are fed by the workers. After several molts they develop into workers or soldiers. Some develop into reproductives, which become winged only when they fly together in a swarm, mate, and found new colonies.

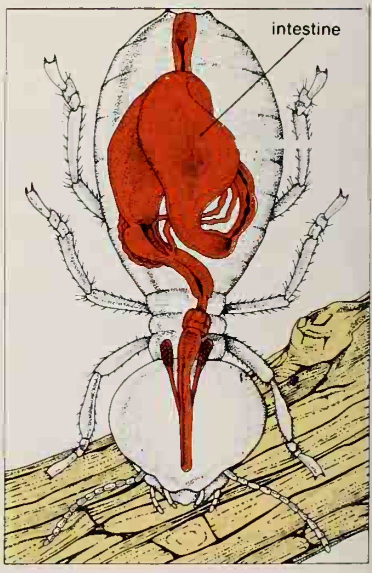
Structure. Primary reproductives have two pairs of wings on the thorax. They range from 5 to 22 mm (0.2 to 0.8 in) in length and are brown to black in color. The head is round, the mouthparts bite, the antennae are many-segmented, and the eyes are compound. Two small claws are borne at the end of each leg. No external genital organs are present. Workers are usually smaller than the reproductives and in most species lack eyes. They never have wings. The soldiers, which form 5 percent of the total colony, are the defensive elements. Their heads are generally so extremely modified for this function that they are unable to feed themselves. Their weapons are their powerful jaws, chemical secretions, or both. Some of the damp-wood termite species have soldiers with very large, heavily armored head capsules and powerful cutting jaws. Those of other species have scissorlike mandibles. The so-called nasute soldiers have a frontal gland that opens through a pore on the top of a nozzle-shaped head. When the soldier bites, a droplet of toxic or sticky secretion squirts out of the gland. The liquid dries in the air, forming a sticky thread that entangles the adversary.

Defense and Nest Structure. The defenses of soldiers are directed against ants, the main predators of termites in most parts of the world. The nest is adapted to withstand incursions of other insects and effects of climate. It also provides a milieu for the development of the brood and fungus gardens, which are tended by the workers.

The most primitive nests are simple burrows in wood.

(Below) *Termite colonies* (A) *consist of specialized forms, such as the reproductive queen* (1) *and king* (2), *worker* (3), *and soldier* (4). *Winged reproductive termites* (B) *mate and form new colonies once a year. Termite mounds* (C) *contain interconnected cavities, and tunnels lead to food.* (Right) *Termites contain numerous symbiotic protozoans (minute organisms) within their intestine, which break down wood cellulose to digestible glucose.*





Nests on trees or mound nests on the ground comprise chewed vegetable material mixed with clay or fecal material. The mounds of certain species of *Macrotermes* rise as high as 6 m (20 ft) in savanna regions of West Africa. The hive of the nest is near ground level and contains the queen cell, brood chambers, and fungus gardens. Workers leave the nest through subterranean tunnels. Foraged vegetable matter is stored in the upper part before being incorporated into the fungus gardens.

tern A tern is a slender seabird with a pointed, straight bill; long, pointed wings; relatively short legs with webbed or partially webbed feet; and often a forked tail. Sometimes known as sea swallows, terns are most common along coastal regions but are also found in midocean and along marshes and rivers. About 40 species, closely related to gulls, skuas, and skimmers, make up the subfamily Sterninae of the family Laridae. Many species are highly migratory, the most spectacular being the Arctic tern, *Sterna paradisaea*, which nests within the Arctic Circle and winters in Antarctica—an annual round trip of more than 17,500 km (11,000 mi).

Terns vary in size from the 20-cm (8-in) little, or least, tern, *S. albifrons*, to the Caspian tern, *S. caspia*, often more than 50 cm (20 in) long. Most terns are typically white with a grayish back and a black cap. Some species, particularly marsh terns (genus *Chlidonias*), have blackish plumage; some, including many noddies (genus *Anous*), are brownish or sooty-colored; and one, the fairy tern (*Gygis alba*), is entirely white.

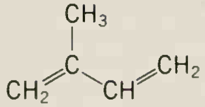
Most terns dive into the water to capture prey. Fish is the main food item. The majority of terns nest in large colonies. Nests are built on the ground or sometimes in low bushes. The one to three eggs and the young are usually cryptically colored.

The common tern, a pigeon-sized seabird related to the gull, is the most frequently seen tern in North America. The black tern (in flight) *builds its nest in shallow water. Unlike most terns, it searches for food on land as well as in the water.*

terpene [tur'-peen] A terpene is a naturally occurring organic compound with the general formula $(C_5H_8)_n$. Until recently this definition was used rather strictly. The term *terpenoid*, referring to related compounds containing oxygen, has fallen into disuse, and both classes are now known as terpenes.

The terpenes share a common general formula and often have structures related to the diene isoprene:

isoprene
(2-methyl-1, 3-butadiene)



The number of isoprene units serves as the most common classification system for the large number of known terpenes. The German chemist Otto Wallach received the Nobel Prize for chemistry in 1910 for his extensive studies of terpene chemistry.

Many terpenes are commercially valuable. For example, the monoterpenes and sesquiterpenes are major constituents of many essential oils prized as perfumes and flavors. There are important relationships between the higher terpenes and the steroids, carotenoids, and vitamins. The carotenoid β-carotene (a tetraterpene) is related to vitamin A (a diterpene). A spectacular example of biogenesis involves the conversion of the triterpene squalene ($C_{30}H_{48}$) found in shark-liver oil into the steroid cholesterol. Natural and synthetic RUBBERS, both examples of the polyterpenes, contain 4,000 to 5,000 isoprene units. Until the relationship of the isoprene units to each other was appreciated (1955), good synthetic rubber could not be produced.

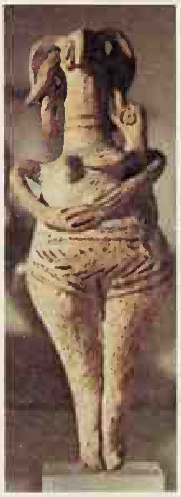
Terra, Gabriel [tay'-rah] Gabriel Terra, b. Aug. 1, 1873, d. Sept. 15, 1942, was president of Uruguay from 1931 to 1938. He was a member of the Colorado party, whose leader, José Batlle y Ordóñez, had, in the second decade of the 1900s, initiated programs that turned Uruguay into a welfare state. In 1933, Terra, in collaboration with Blanco party leader Luis Alberto de Herrera, suspended congress, abolished the constitution, and created a dictatorship. After the new constitution of 1934 formalized a Blanco-Colorado patronage-sharing arrangement and enhanced executive power, Terra was reelected. He extended Batlle's welfare policies, but he repressed dissent and governed largely by decree.

terra-cotta [te'-rah kot'-tuh] Terra-cotta (Italian for "baked earth") is a type of hard-baked clay, or earthenware, produced by means of a single firing. Usually rendered brownish red in color after firing, terra-cotta may be either glazed (covered with a layer of molten glass) or left in its natural state, in which it is sometimes referred to as "biscuit."

Ancient Traditions. Terra-cotta objects unearthed at sites in widely separated regions provide clear evidence of the manifold uses that prehistoric and ancient peoples found for this earthenware. Despite its porous nature, terra-cotta from earliest times served a general purpose in the making of domestic pots; at a later stage of development, glaze was lightly applied to the interior of terra-cotta vessels to render them watertight (see POTTERY AND PORCELAIN). Terra-cotta art flourished simultaneously in a wide range of early cultures. Among the many types of terra-cotta sculpture produced in the ancient world were votive figures associated with the fertility cults practiced by the inhabitants of the Indus Valley (3d–2d millennia BC); Japanese figures dating from the Jomon (3d–2d millennia BC) and Haniwa periods (AD 300–645); finely modeled figures executed by the artisans of the ancient Aegean, Egyptian, and Greek civilizations; pre-Columbian American figurines dating from *c.*2000 BC; and large freestanding statuary executed (from the 5th century BC) by artists of the prehistoric Nok culture of present-day northern Nigeria.

This bodhisattva (7th-8th century), sculpted from coarse terra-cotta, was discovered in a Buddhist monastery in Fodukistan, Afghanistan. The execution of the sculpture combines traditional Indo-Iranian influences with the traditions of indigenous artists. Statues sculpted in this manner were supported by a wooden core and were often painted and gilded. (Musée Guimet, Paris.)

(Right) *This terra-cotta figurine dates from Hellenistic times. (Louvre, Paris.)* (Below) *This terra-cotta statuette (14th-13th century* BC*) exemplifies a fertility image common in Aegean Bronze Age art.*



Mesopotamian tombs of the 3d–2d millennia BC have been found to contain singular, shoe-shaped coffins made of terra-cotta coated with a vitreous saline glaze, as well as terra-cotta toys, votive offerings, and various utilitarian and ornamental objects. By about 2000 BC the Assyrians and Babylonians had discovered how to use copper to obtain a rich turquoise blue coloring that could be applied to decorative terra-cotta tiles.

Among all the civilizations of the ancient world, the Greeks used terra-cotta in the most varied ways, producing all kinds of domestic wares, ornaments, and sculptures as well as large-scale objects such as sarcophagi. Greek sculptors used terra-cotta to produce models for bronze statues. From early small statuettes that served religious or funerary functions, Greek terra-cotta figures evolved (*c.*7th century BC) into highly artistic creations that displayed exquisite artistry. During Greece's Classical period (6th–5th centuries BC), Tanagra, in Boeotia, became the leading center of production of terra-cotta figurines. Etruscan sculptors and potters learned terra-cotta work from Greek artists, as did Roman sculptors.

Renaissance to the Present. With the end of the Roman Empire (5th century), the artistic use of terra-cotta largely ceased in Europe until the late 14th century, when molded terra-cotta details began to appear on buildings in Germany and Italy. During the Early Renaissance period (*c.*1415–1500) in Italy, such sculptors as DONATELLO, Jacopo della Quercia, and Andrea del VERROCHIO executed both freestanding and relief sculptures in terra-cotta. Luca Della Robbia (see DELLA ROBBIA family), a Florentine sculptor, produced brilliantly enameled plaques and medallions in MAJOLICA (terra-cotta highly decorated with enamels and luster pigments).

The use of terra-cotta for decorative work in architecture spread (16th century) from Italy to the rest of Europe and remained popular until the 18th century, by which time it had been superseded almost completely by marble. In the late 19th and early 20th centuries, however, the use of molded terra-cotta ornaments and decorative fittings was revived by several American architectural firms, most notably Adler and Sullivan of Chicago.

Meanwhile, terra-cotta experienced two waves of popularity in Great Britain. Josiah Wedgwood revived interest in terra-cotta in the late 1760s, when he introduced his improved earthenware, a harder and less brittle terra-cotta body produced by adding a proportion of calcined flint and pulverized potash to iron-free potter's clay. Then, in the mid-19th-century Victorian era, a passion for bright-hued terra-cotta statuary, garden ornaments, plaques, medallions, fountains, and figures on pedestals swept across the country.

In the 20th century, terra-cotta has been used extensively as both a building material and a decorative medium, and such major sculptors as Aristide Maillol and Pablo Picasso produced significant works in terra-cotta.

Terre Haute [tair'-uh hoht] Terre Haute (1990 pop., 57,483), a city in western Indiana and the seat of Vigo County, is situated on the Wabash River about 110 km (70 mi) west of Indianapolis. A commercial center in a coal-mining and agricultural area, the city manufactures bricks, tiles, bottles, steel products, and foodstuffs. Indiana State University (1865) is located there.

Laid out in 1816, Terre Haute began to grow after the construction of the National Road (1838), the Wabash and Erie Canal (1849), and the Richmond Railroad (1852). Discovery of coal in 1875 prompted industrial development. The birthplace of the labor organizer and founder of the U.S. Socialist party, Eugene V. Debs, Terre Haute was known for its militant union activity.

territorial waters Territorial waters are considered by international law those waters which fall within the jurisdiction of sovereign states. These waters include waters immediately adjacent to a nation's shoreline. In the 18th century the extent of shoreline territorial waters was fixed at 3 mi (4.8 km) from the low watermark or straight coastal baseline, a distance determined on the basis of cannon-firing range at that time. As with inland territorial waters, the seabed and its subsoil, as well as the airspace above them, come under the exclusive jurisdiction of a sovereign state, except in the case of innocent passage—the peacetime transit of merchant ships. Innocent passage does not include the right to fish or the traffic of submerged submarines. Lakes or rivers on national boundaries are under national control to the middle of navigable channels. With the adoption (1982) of the United Nations Convention on the Law of the Sea (see Sea, Law of the), rules for all parts and uses of the sea have been established. A key feature of the international treaty that pertains to coastal nations includes a 12-naut-mi (22.2-km) sovereignty limit with the right of innocent passage of foreign vessels.

See also: SEAS, FREEDOM OF THE.

territoriality Territoriality is broadly defined as the defense of space; in particular, territorial behavior among many animals serves to exclude other individuals of the same species from areas of mating and breeding. For example, a male robin announces his claim to a patch of land in the spring by repeatedly singing his species' song. An intruder male that enters this patch will usually be quickly chased away, but occasionally the two males will fight for the territory, which in rare cases will change hands. The territorial competition among male robins eventually results in the subdivision of a woodlot into a mosaic of plots, each of which is held by one male (see bird). A female is attracted to and mates with a male who holds a territory, and the pair then raises a clutch of young on the plot.

Certain limpets (marine mollusks), using their hat-shaped shells to push opponents away, defend small areas on tidal-zone rocks that have the thick algal patches on which they feed. Among the many territorial insects are the huge cicada-killer wasps, which engage in aerial aggression against one another to establish territories near areas where females are emerging from underground cells.

Territoriality has reproductive benefits (exclusive use of the resources in an area) and reproductive costs (the time, energy, and risks taken to exclude others from the territory). In general, the scarcer the resource, the more valuable its possession and the greater the gain from territoriality. Animals will be territorial only when their living space contains or attracts a limited resource that enhances individual reproductive success. Territorial songbirds defend woodlot areas best suited for rearing a brood; these areas contain above-average supplies of food and good nesting sites. The limpet defends a concentration of food as well as a secure resting site that protects it from waves.

In some species, ownership of territory is a precondition for acceptance by a female. For example, in sage grouse, certain African antelopes, and some hummingbirds, males gather in groups and compete for ownership of a small patch of ground or areas about a perch. Females come to the group display area, known as a lek, to select as mates those males which hold certain territories. These males, because they have been able to exclude all others from the prime sites, have demonstrated their competitive superiority and are therefore consistently chosen by visiting females. In lek species, territoriality gives a male a chance to attract a limited resource, namely, receptive females.

Territories generally tend to be relatively small compared to the undefended home ranges of many animal species. The larger the territory, the greater the area from which intruders need to be expelled; more time and energy are required, therefore, to enjoy the benefits of sole ownership of the resources contained in the area. As a result animals tend to defend resources that are concentrated in a small, defensible site and not resources that are scattered over a broad area. Territories, moreover, shrink in size as the number of competitors increases and may even be abandoned if the intruder rate passes a certain point. For example, African sunbirds defend feeding territories that contain nectar-producing flowers only if some patches are much more productive than others and only if intruders are relatively few; because of this particular territorial behavior, the costs of defense are minimal.

territory In government a territory is that part of a country which has not been admitted to full and equal status within the larger union or federation. In the United States the Ordinance of 1787 set out a plan for administering the Northwest Territory, an area lying between the Ohio and Mississippi rivers. It included provisions for basic civil and political rights and eventual admission—if self-government seemed secure—as a state. The Northwest Ordinance served as the model for the regulation of later territories such as the Louisiana and the Oregon territories, and 31 states were territories or parts of territories before being admitted to the Union. The U.S. Constitution (Article IV, Section 3) empowered Congress to control territories.

All of the territories contiguous to the United States had been admitted as states by 1912, and Alaska and Hawaii by 1959. (Australia and Canada still have contiguous territories.) Puerto Rico, a U.S. territory since the Spanish-American War, secured commonwealth status in 1952, becoming the most autonomous of all U.S. territories. All U.S. territories are administered by the Office of Territorial and International Affairs of the Department of the Interior. Included are the territories of Guam, American Samoa, the Virgin Islands, the Commonwealth of the Northern Mariana Islands, and the Trust Territory of the Pacific Islands (see PACIFIC ISLANDS, TRUST TERRITORY OF THE).

See also: TRUST TERRITORY.

terrorism Terrorism is the sustained, clandestine use of violence—murder, kidnapping, bombings—to achieve a political purpose. Definitions in the U.S. Intelligence and Surveillance Act of 1979 and the United Kingdom Prevention of Terrorism Act of 1976 stress the use of violence to coerce or intimidate the civilian population with a view to affecting governmental policy. In popular usage, however, as influenced by politicians and the media, *terrorism* is now increasingly used as a generic term for all kinds of political violence, especially as manifested in revolutionary and guerrilla warfare.

Nevertheless, not all political violence short of conventional war is terrorism. Political assassination may or may not be a terrorist act, depending on the degree of commitment to a sustained program of terror. Assassinations of Tsar Alexander II and other prominent figures in imperial Russia by nihilists and social revolutionaries were part of a sustained program of violence aimed at bringing down the tsarist regime and as such were terrorist acts. On the other hand, the assassinations of Presidents Abraham Lincoln and John F. Kennedy, while undoubtedly political in motive, were not part of a sustained program and hence cannot properly be called terrorism. The term is inappropriately applied to the suicide attacks of religious fanatics on military personnel in a war zone, as in the case of the bombings of U.S. Marine and French Foreign Legion bunkers in Lebanon in 1983, although not to the bombings of the U.S. Embassy (1983–84).

The deliberate killing of civilians to intimidate the civilian population or government is one of the worst features of contemporary terrorism and can clearly be distinguished from the type of clandestine warfare waged by resistance groups or insurgency movements against official and military targets. By their actions the PALESTINE LIBERATION ORGANIZATION (PLO) and the Provisional Wing of the IRISH REPUBLICAN ARMY (IRA) are terrorist organizations. But one would not use the term to describe the Polish and French underground resistance movements of World War II. When governments engage in illegal and clandestine kidnapping and murder to intimidate their people—as in the case of the Nazis in Germany and the Argentine military junta in power from 1976 to 1983—the term *state terrorism* is appropriate.

One key characteristic of modern terrorism is its effort to attract media coverage. Terrorist atrocities such as the PLO's murder of helpless athletes at the 1972 Olympics are perpetrated to publicize a cause. Most of the victims of the Italian Red Brigades and the German Baader-Meinhof gang were selected for symbolic reasons. Another characteristic of modern terrorism is its international dimension—the ability of terrorists to slip across national frontiers, the support given to certain terrorist groups by a few countries dedicated to revolutionary change, and logistical ties that exist between terrorist groups of widely divergent ideologies and objectives. The 1985 hijacking by Palestinians of the Italian cruise ship *Achille Lauro* off Egypt, and the murder of a U.S. passenger, dramatized the international ramifications of terrorism.

Whereas prevention of domestic terrorism is in general the province of local law-enforcement agencies or security forces, at the international level effective counterterrorist action runs into obstacles raised by traditional concepts of national sovereignty. In theory, perpetrators of crimes in one country can, if apprehended in another country, be extradited for trial. In practice, however, law-enforcement officials tend to give foreign fugitives from justice a low priority. Moreover, a well-established exception for political offenses may protect from extradition all but the most flagrant offenders.

In recent years international efforts to counter terrorism have led to the Tokyo and Montreal Conventions (1963 and 1971) on hijacking and sabotage of civilian aircraft; the Hague Convention of 1979 on hostage-taking; and the 1973 convention on crimes against diplomats. These conventions established categories of international crimes that are punishable by any state regardless of the nationality of criminal or victim or locality of the offense.

Today the most effective means of frustrating terrorist activity is through detailed intelligence obtained primarily by penetration of terrorist networks.

Terry, Dame Ellen Alice The most celebrated English actress of her day, Ellen Terry, b. Feb. 27, 1847, d.

July 21, 1928, played with Sir Henry Irving in Shakespeare and romantic melodrama at London's Lyceum Theatre from 1878 to 1902. She remained a great theatrical personality until the 1920s. George Bernard Shaw wrote *Captain Brassbound's Conversion* especially for her, and her published correspondence (1931) with the great playwright reveals her own considerable literary talent. Terry was the mother of the set designer Gordon Craig. She was made a Dame of the British Empire in 1925.

Tertiary Period see EARTH, GEOLOGICAL HISTORY OF; GEOLOGIC TIME

Tertullian [tur-tul'-ee-uhn] Quintus Septimius Florens Tertullianus, b. Carthage, *c.*155, d. after 220, was one of the greatest Western theologians and writers of Christian antiquity. Through his writings a witness to the doctrine and discipline of the early church in belief and worship is preserved.

An advocate in the law courts in Rome, Tertullian converted (*c.*193) to Christianity. About 207 he broke with the church and joined the Montanists (see Montanism) in Africa. Soon after, however, he broke with them and formed his own party, known as the Tertullianists.

An extremist by nature, he had gone through a period of licentiousness during his early years, but later he advocated a severe asceticism and discipline that his followers found hard to emulate.

Tertullian wrote with brilliant rhetoric and biting satire. His passion for truth led him into polemics with his enemies: in turn pagans, Jews, heretics, and Catholics. His admiration for Christian heroism under persecution seems to have been the strongest factor in his conversion.

Tesla, Nikola [tes'-luh] The Croatian-American electrical engineer and inventor Nikola Tesla, b. July 9, 1856, d. Jan. 7, 1943, made practical the use of ALTERNATING CURRENT. After emigrating (1884) to the United States, he worked briefly for Thomas Edison. In 1888 he demonstrated how a magnetic field could be made to rotate if two coils at right angles were supplied with alternating current of different phases (90 degrees out of phase with each other). Tesla patented his alternating-current MOTOR, which was purchased by George Westinghouse and made the basis for the Westinghouse power system.

After 1903, Tesla did noteworthy research on high-voltage electricity, transformers, telephone and telegraph systems, and plants for power transmission without wires.

Tessai [tay-sy] Tomioka Tessai, 1836–1924, was a Japanese artist who carried the Nanga school of Japanese painting into the modern era. Born in Kyoto, he was educated in Shinto, Confucianism, Buddhism, and Japanese literature. As a Shinto priest Tessai allied himself with the forces seeking a restoration of imperial rule and was forced to flee to Nagasaki, where he studied the Chinese-derived literati style known as Nanga. Tessai produced more than 20,000 paintings of traditional Chinese and Japanese subjects.

test see EDUCATIONAL MEASUREMENT AND TESTING; PSYCHOLOGICAL MEASUREMENT

Test Acts Test acts were laws passed in post-Reformation England, Scotland, and Ireland to limit office holding to those professing the established religion. In England the Test Act of 1673 was passed by Parliament to exclude from public office all persons refusing to take oaths of allegiance and supremacy to the crown or to receive the sacraments according to the rites of the Church of England. The legislators feared that King Charles II's alliance with France and his Declaration of Indulgence (1672), suspending the penal laws against Roman Catholics, would lead to the revival of Roman Catholicism as the national religion. The act was extended in 1678 to members of Parliament. Thus non-Anglicans were formally excluded from public life. Roman Catholic King James II (r. 1685–88) was unable to secure repeal. After 1689, however, it became customary to pass bills of indemnity legalizing the acts of nonconforming magistrates. The Test Act remained law until 1828, a year before Catholic Emancipation restored other civil rights to Roman Catholics. Test acts were abolished in 1871 in Ireland and in 1889 in Scotland.

testicle see REPRODUCTIVE SYSTEM, HUMAN

testosterone see SEX HORMONES

tetanus [tet'-nuhs] Tetanus, or lockjaw, an acute and often fatal infectious disease of the human nervous system, is characterized by severe spasms of the voluntary muscles and convulsions. The symptoms are caused by a toxin produced by *Clostridium tetani*, an anaerobic bacterium that can infect deep wounds where oxygen is unavailable; its spores can be found in soil and in animal feces. The incubation period is usually 5 to 10 days, and the most frequently occurring symptom is jaw stiffness, which progresses to trismus—difficulty in opening the jaws. Other symptoms include difficulty in swallowing, stiffness of the arms or legs, fever, headache, and sore throat. Convulsions can result in death through suffocation. The prognosis is poor if symptoms progress rapidly or treatment is delayed. Treatment includes tetanus antitoxin, and the disease can be prevented by immunization with toxoid.

Tethys Sea see PALEOGEOGRAPHY

Teton Dam [tee'-tuhn] The Teton Dam and Reservoir were the principal features of the Teton Basin Project on the Teton River in southeastern Idaho. This multipurpose project was designed to provide irrigation, power production, flood control, and recreation. The project was begun in 1972, despite controversy over the safety of the dam site. Reservoir filling began in October, 1975 when the river outlet was closed. On June 5, 1976, the earth embankment dam collapsed as a result of the internal erosion of the core material. The wall of water released by the collapse killed 11 people, left more than 25,000 homeless, and flooded a 780-km^2 (300-mi^2) area.

Teton Range The Teton Range, a chain of the Rocky Mountains, extends immediately south of Yellowstone National Park in northwestern Wyoming and eastern Idaho. About 65 km (40 mi) long, it lies partly within Grand Teton National Park and Bridger-Teton and Targhee national forests. The highest peak, Grand Teton (4,199 m/ 13,776 ft), was first scaled by Nathaniel P. Langford and James Stevenson in 1872. Jackson, Wyo., a popular tourist center, is to the south. John Colter was the first white person to explore (1807–08) the range.

tetra [tet'-ruh] Tetras are any of a number of small, active, attractively colored or marked freshwater fishes of the family Characidae (the characins). Native primarily to tropical America, many of these fishes were once classified in the genus *Tetragonopterus*, from which the common name is derived. Tetras are popular aquarium fishes and are bred on a large scale.

tetracycline see antibiotics

tetragonal system [te-trag'-uhn-uhl] Crystals that can be referred to three mutually perpendicular axes, two of which are of equal length, belong to the tetragonal system. This system contains seven classes. The symmetry element that distinguishes tetragonal crystals from crystals of other systems is a unique fourfold symmetry axis coincident with the *c* crystallographic axis. Common minerals belonging to the tetragonal system include chalcopyrite, idocrase, rutile, scapolite, and zircon. Crystals in the highest-order class in this system can possess as many elements as one fourfold symmetry axis, four twofold symmetry axes, and five planes of symmetry. Crystals of the lowest-order class possess only a unique fourfold inversion axis.

Tetragonal crystals are optically uniaxial, and, as in the hexagonal system, the optical axis coincides with the *c* (fourfold) crystallographic axis. Extinction is always parallel in crystals belonging to this system.

tetrahedrite [te-truh-hee'-dryt] The widely distributed copper and iron antimony sulfide mineral tetrahedrite $[(Cu, Fe)_{12}Sb_4S_{13}]$, a copper ore, usually contains some arsenic and thus grades into the associated mineral tennantite. These minerals form gray to black tetrahedral crystals (isometric system), crystal groups, and granular masses. Hardness is 3 to 4½, and specific gravity is 4.4 to 5.1. Occurrences are in medium- to low-temperature ore veins, commonly with chalcopyrite. Major deposits occur in Montana, Bohemia, Hungary, Chile, Peru, and Bolivia.

Tetrazzini, Luisa [tay-trah-tsee'-nee] Luisa Tetrazzini, an operatic soprano, b. Florence, Italy, June 8, 1871, d. April 28, 1940, made her debut at age 19 in Meyerbeer's *L'Africaine* at the Teatro Pagliano (now Teatro Verdi) in Florence. She spent several years in Argentina and Brazil and was first heard in New York at the Manhattan Opera House, as Violetta in Verdi's *La Traviata*. She made her last public appearance at the Paramount Theater, New York City, in 1931, and retired to teach in Milan. Her voice coupled fluency in coloratura with unusual fullness and richness.

tetrode see electron tube

Teutonic Knights [too-tahn'-ik] Founded in 1190 by German merchants to serve a hospital during the siege of Acre in the Third Crusade, the Teutonic Knights were originally called the Brothers of the Hospital of Saint Mary of the Teutons in Jerusalem. By 1198 they had become a military order similar to the Templars and Knights Hospitalers. The members, who were nobles, took vows of poverty, chastity, and obedience. During the 13th century the order moved to eastern Europe and began its principal work—crusading against the pagan peoples in the east. Under the leadership of Hermann von Salza, grand master from 1210 to 1239, the order began to carve out for itself the military-monastic state of Prussia. By its administration and colonization it played a central role in the eastward expansion of German culture and power—the Drang nach Osten.

In 1237 the Teutonic Knights merged with the Livonian Knights, who had created a similar domain for themselves in the Baltic lands (see Livonia). Their eastward expansion was halted (1240) by defeat at the hands of Alexander Nevsky. The order made repeated and unsuccessful attempts to conquer Lithuania, which it continued to threaten even after Lithuania entered into (1386) a personal union with Poland and converted to Latin Christianity. In 1410, Polish-Lithuanian forces defeated the Knights in the Battle of Tannenberg.

During the 16th century the order's grand master, Albert of Brandenburg, converted (1525) to Lutheranism and declared Prussia a secular duchy (see Albert, 1st Duke of Prussia). At this point the Livonian Knights resumed their independence until they were dissolved in 1561. A remaining branch of the order retained lands in central and southern Germany until 1809. Today the order is reorganized as a clerical order engaged in pastoral work and health care.

Texarkana [tek-sar-kan'-uh] Texarkana is a city bisected by the Texas-Arkansas border, about 260 km (160 mi) northeast of Dallas, Tex. The Arkansas section, which is the seat of Miller County, has a population of 22,631

(1990); the Texas section has 31,656 residents. The industry of the dual municipality, which has separate governments, includes processing and distribution of cotton and lumber and manufacture of clay products, tires, furniture, and mobile homes. The city is a railroad junction and has several U.S. Army installations. It was settled in 1874.

Texas Stretching 1,244 km (773 mi) from east to west and 1,289 km (801 mi) from north to south, Texas, the Lone Star State, occupies almost 7.5% of the nation's total land area—a region as large as all of New England, New York, Pennsylvania, Ohio, and Illinois combined. With its 17,059,805 inhabitants (1990), Texas is the third most populous state in the country. It derives its name from the Spanish and Indian words *tejas* and *techas*, meaning "friends" or "allies."

Texas shows the influence of both the Indians and the Spanish, French, and other European explorers and missionaries. In 1820, Moses and Stephen F. Austin started the Anglo-American colonization that culminated in the organization of a provisional government at San Felipe on Nov. 3, 1835, and in independence from Mexico on Mar. 2, 1836. After almost 10 years as an independent republic, Texas became a U.S. state on Dec. 29, 1845.

The modern economic development of Texas started in January 1901 with the eruption of an oil well drilled at Spindletop, near Beaumont. The rapid discovery of oil in various other parts of the state led to a boom that has never really stopped. The economy of Texas has become highly diversified, and its population has more than quadrupled during this century.

Land and Resources

Topography and Soils. Four major physiographic subdivisions of North America are found in Texas: the Gulf Coastal Plain in the east and southeast, the North Central Plains in the center of the state, the Great High Plains in the northwest, and the Trans-Pecos Mountains to the extreme west and southwest. The topography of Texas rises gradually from east to west, reaching its highest point in Guadalupe Peak (2,667 m/8,749 ft) in the Trans-Pecos.

The Gulf Coastal Plain, extending about 80 to 100 km (50 to 60 mi) inland from the Gulf of Mexico, from sea level to an altitude of about 150 m (500 ft), has a rolling-to-hilly surface. Its western part consists of a fertile belt of land of irregular width known as the Blackland Prairie.

Inland from the Coastal Plain, the North Central Plains of Texas are the southern extension of the GREAT PLAINS and reach southwestward across the entire state to the Rio Grande. The plains' southern portion is known as the

AT A GLANCE

TEXAS

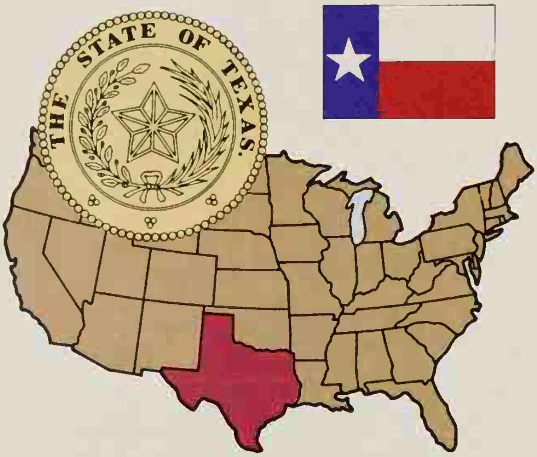
Land: Area: 695,674 km^2 (268,601 mi^2); rank: 2d. Capital: Austin (1990 pop., 465,622). Largest city: Houston (1990 pop., 1,630,553). Counties: 254. Elevations: highest—2,667 m (8,749 ft), at Guadalupe Peak; lowest—sea level, at the Gulf of Mexico.

People: Population (1990): 17,059,805; rank: 3d; density: 25 persons per km^2 (64.9 per mi^2). Distribution (1990): 80.3% urban, 19.7% rural. Average annual change (1980–90): +2.0%.

Government (1993): Governor: Ann Richards, Democrat. U.S. Congress: Senate—1 Democrat, 1 Republican; House—21 Democrats, 9 Republicans. Electoral college votes: 32. State legislature: 31 senators, 150 representatives.

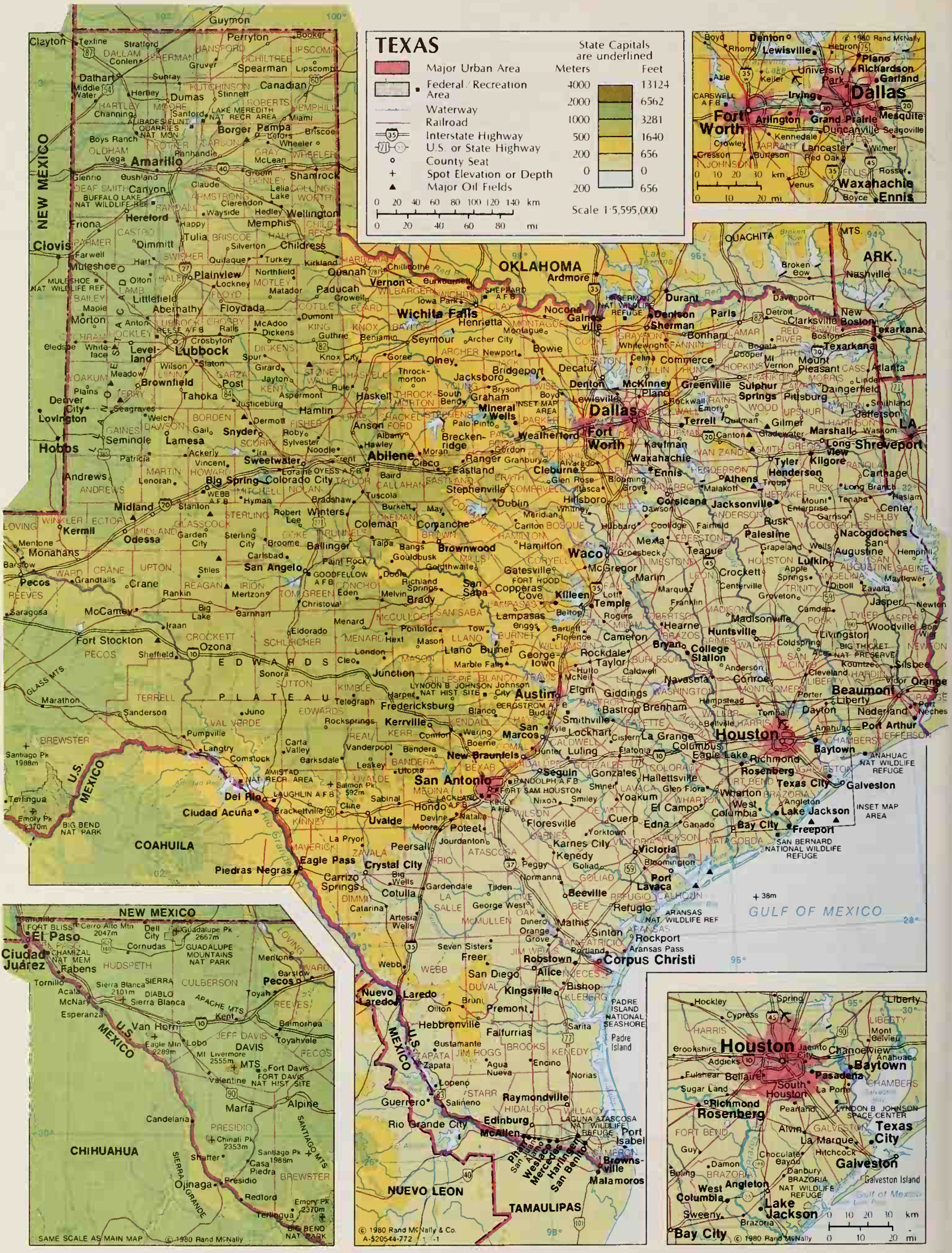
Economy: State personal income (1989): $266.8 billion; rank: 3d. Median family income (1989): $31,553; rank: 35th. Agriculture: income (1989)—$10.8 billion. Fishing: value (1989)—$170 million. Lumber production (1991): 1.1 billion board feet. Mining (nonfuel): value (1988)—$1.5 billion. Manufacturing: value added (1987)—$63.9 billion. Services: value (1987)—$69.9 billion.

Miscellany: Statehood: Dec. 29,1845; the 28th state. Nickname: Lone Star State; tree: pecan; motto: Friendship; song: "Texas, Our Texas."



Mockingbird

Bluebonnet



CONTINUED ON INSET

Edwards Plateau. The border of the North Central Plains on the west is the Staked Plain, or Llano Estacado in Spanish. It consists of a flat-topped tableland with an elevation of about 1,200 m (4,000 ft). Lying between Mexico and New Mexico, the barren Trans-Pecos region in southwestern Texas alternates between rolling hills in the Pecos River valley and the isolated high ridges of the Guadalupe and Davis mountains.

Texas soils vary greatly in depth from one region to another and show different physical properties; all need fertilizing, however, and some need irrigating to make them productive.

Rivers and Lakes. Texas has two sources of water: aquifers, found under more than half the state, and streams with their reservoirs.

Among the major rivers in Texas are the RIO GRANDE, which constitutes the border with Mexico; the RED RIVER, which partly separates Texas from Oklahoma and Arkansas; the COLORADO RIVER of Texas (965 km/600 mi), which is the longest river entirely within the state; and the Sabine, which forms the southern half of the boundary between Texas and Louisiana. Other rivers include the PECOS and the Devils, both tributaries of the Rio Grande; the Nueces; and the Guadalupe.

Texas has relatively few natural lakes but hundreds of artificial ones. These were developed to provide hydroelectricity, to store water, or to irrigate farmland. Among the largest are Lake Texoma (partly in Oklahoma) on the Red River and the Falcon and Amistad reservoirs on the Rio Grande.

Climate. The climates of Texas range from the hot subhumid found in the Rio Grande valley to the cold semiarid of the northern part of the Panhandle, and from the warm humid in the east to the arid of the Trans-Pecos. Rainfall varies from 1,400 mm (55 in) in the east to less than 250 mm (10 in) in the west. Drought can be a serious problem, especially in the Great High Plains. Temperatures, too, vary greatly, ranging from 49° C (120° F) to −31° C (−23° F). Each year about 100 tornadoes occur, most frequently in the Red River valley.

Vegetation and Animal Life. The dense pine forests of eastern Texas contrast with the deserts of the western part of the state, and the grassy plains of the north contrast with the semiarid brush of southern Texas. Eastern Texas vegetation is characterized by dense pine forests and a variety of hardwoods including oak, hickory, ash, and magnolia. The central region is dominated by oak, elm, and pecan, as well as, on the Edwards Plateau, by cedar and mesquite. Shrubs of the grasslands of the lower altitudes of the west include acacia, mesquite, and mimosa; the Trans-Pecos Mountains have pine, fir, and spruce. The Rio Grande valley is mostly covered by brush, mesquite, cedar, post oak, and in places a dense growth of prickly pear. In the southwest are found cactus, agave, and yucca.

Texas is the temporary home every year for many migratory birds. Aransas Wildlife Refuge, for example, on the Gulf above Corpus Christi, provides the winter quarters for the almost extinct whooping crane. The state's indigenous animals include the mule and white-tailed deer, black bear, mountain lion, antelope, and bighorn, but the American bison, or buffalo, is found only in zoos and on a few ranches. Among the smaller mammals are the muskrat, raccoon, opossum, jackrabbit, fox, mink, coyote, and armadillo.

Resources. Minerals represent a very significant part of the state's natural wealth. The known petroleum deposits of Texas—about 8 billion barrels—make up approximately one-third of the known U.S. supply. The Texas Panhandle is one of the world's great natural-gas reservoirs. Mineral fuels generally account for over 90% of the value of all minerals produced in the state, although Texas is also a leading producer of natural graphite, magnesium, sulfur, and cement and has considerable reserves of lignite (low-grade coal). Uranium is also mined.

People

Although surpassed in population only by California and New York, Texas is still considerably less crowded than the nation as a whole. Yet the state's population in-

Oil-rich Houston, the largest city in Texas, has become a showcase of contemporary architecture. At the center of this view of the downtown area is the Republic-Bank Center (1983). Its red granite and stepped gables contrast strikingly with more traditional skyscrapers.

Cattle are herded across rangeland in Texas. Because of the mild climate, beef cattle can graze outdoors throughout the year, and Texas leads the nation in their output.

creased by 52% between 1970 and 1990—more than double the national average (23%)—partly as a result of in-migration. Most of the population increase since World War II has been within the state's metropolitan areas, especially the suburbs. In 1990 the state's ten largest metropolitan areas accounted for nearly half of its population.

Racially, Texas is made up of whites, who constitute 75.2% of the population; blacks, 11.9%; and other nonwhites, 12.9%. Persons of Spanish origin account for 25.5% of the population. European settlers during the 19th and early 20th centuries included Germans, Swedes, and Czechs.

Counties and Cities. Texas has 254 counties ranging in population from 107 (Loving County, 1990) to 2,818,199 (Harris, 1990), and in size from Rockwall's 386 km^2 (149 mi^2) to Brewster's 16,035 km^2 (6,191 mi^2), nearly equal to the combined areas of Connecticut and Rhode Island. Major cities include the capital, AUSTIN; the state's largest city, HOUSTON; and DALLAS and FORT WORTH, only about 50 km (30 mi) apart. SAN ANTONIO is a fast-growing shipping center for oil and agricultural products; other important commercial centers are ABILENE, AMARILLO, BEAUMONT, BROWNSVILLE, CORPUS CHRISTI, EL PASO, GALVESTON, LAREDO, LUBBOCK, MIDLAND, PORT ARTHUR, WACO, and WICHITA FALLS.

Education. In 1839, Texas president Mirabeau B. LAMAR set aside land in each county for public schools and for a state university. Today the average daily attendance in Texas public schools exceeds 2 million, and higher education in the state includes almost 100 public institutions, including the University of Texas (see TEXAS, UNIVERSITY OF). Texas also has several dozen private institutions of higher education (including BAYLOR, RICE, and Southern Methodist (1910) universities).

Culture and Historical Sites. Texas has several hundred public libraries—the largest being those in Dallas and Houston; the libraries of the University of Texas at Austin have the state's largest collections. There are more than 300 museums, and there are 3 major symphony orchestras—in Dallas, Houston, and San Antonio. Among the outstanding museums are the Dallas and Fort Worth museums of fine arts, the McNay Art Institute and Witte Museum in San Antonio, the Museum of Fine Arts, the Contemporary Arts Museum, and the Menil Collection in Houston, and the Amon Carter Museum of Western Art in Fort Worth. Well-known symphony orchestras are also in Amarillo, Fort Worth, and Austin. The Dallas and Austin ballets and the Alley Theatre in Houston have national reputations. The Dallas Civic, Houston Grand, and San Antonio operas are the state's major opera companies.

The ALAMO in San Antonio is the most famous historical site; others are San Antonio Missions National Historic Park, San Jacinto Monument east of Houston, Fort Davis National Historic Site, and the Lyndon Baines Johnson Presidential Library—part of the University of Texas in Austin.

Communications. The first newspaper in Texas, the *Gaceta de Texas* (Texas Gazette), was published in Spanish in 1813 at Nacogdoches. Among the oldest English newspapers are the *Galveston News* (1842) and the *Dallas Morning News* (1885). Texas is well supplied with radio stations, both AM and FM, as well as with television stations.

Economic Activity

For decades oil influenced every aspect of the economic development of Texas. This changed in the mid-1980s when oil prices collapsed devastatingly. Slow economic recovery began in 1987, however, helped by the industrial diversification that had already begun in Texas and that was now intensified. The service industries, notably retail and wholesale trade, contribute well over half of the gross state product of Texas.

Agriculture. Texas is a leading agricultural state, frequently ranking third (after California and Iowa) in gross farm income. The largest share of agricultural income is derived from beef cattle; Texas leads the nation in the number of beef cattle, which usually exceed 14 million head. Cotton is the leading crop and the state's second-most-valuable farm product. Texas also leads in national production of grain sorghum, watermelons, cabbages, and spinach. Wheat, corn, and other grains are also important.

Forestry and Fishing. Production of timber—more softwoods than hardwoods—represents a small share of the gross state product of Texas, but shipments of lumber and wood products and of paper and allied products are worth many times that share. As for fishing, shrimp accounts for over 90% of Texas's total commercial catch.

Mining. Texas is the nation's most important producer of minerals. It leads the nation in the production of mineral fuels, with petroleum the most valuable and natural gas the second most valuable. A foremost state in nonfuel minerals, Texas is a leading producer of natural graphite, magnesium, sulfur, and cement. The eastern part of the state has lignite coal mines. Metals mined in Texas include iron, uranium, magnesium, and sodium.

Manufacturing. Before World War II, manufacturing in Texas centered on processing the raw materials, notably petroleum and agricultural products, available in the state. The decades since the war have seen an emphasis on diversification in manufacturing, however, as well as significant industrial expansion. In the late 1980s, in the wake of the disastrous oil slump, state leaders were attempting to attract more high-tech industries to Texas.

Manufactures include a wide range of petroleum and coal products, nonelectrical machinery, chemicals, and food products. Other broad categories of Texan manufactures include electrical machinery and equipment, fabricated metals, primary metals, and transportation equipment.

Tourism. Texas attracts millions of out-of-state visitors annually. Many visitors explore Dallas, San Antonio, Houston, Fort Worth, El Paso, Austin, and other cities. Sites of special interest range from Nacogdoches in East Texas, one of the state's oldest cities, to the Lyndon B. Johnson Space Center near Houston. Texas's two national parks, Big Bend and Guadalupe Mountains, are also popular. Hunting and fishing are popular pastimes for visitors and Texans alike, as are professional and college sports events.

Transportation. As befits its size, Texas ranks first nationally in total highway and railroad mileage. It also has the most airports (about 1,200). There are 12 deepwater ports along the Gulf of Mexico, with Houston the busiest (and ranking among the most active of all U.S. ports).

Energy. Texas consumes more energy than any other state—more than 60% of its natural gas and about 40% of its oil never leave its borders. About 90% of the energy consumed in Texas comes from petroleum and natural gas.

Government and Politics

The present Texas constitution was adopted on Feb. 15, 1876, but has been amended many times. The chief executive is the governor, who serves for 4 years. Legislative authority is exercised by the senate, with 31 members elected for 4-year terms, and the house of representatives, with 150 members elected for 2-year terms. The highest courts of Texas include the 9-member supreme court and the 5-member court of criminal appeals. Judges of the two courts are elected to 6-year overlapping terms.

Despite the popularity of some individual Republicans, Democrats have dominated state-level politics since Reconstruction; competition occurs chiefly between the liberal and conservative wings of the Democratic party.

History

Evidence of a meeting in eastern Texas between Middle American prehistoric cultures and temple Mound Builders from the eastern part of what is now the United States has been discovered in an Indian mound on the Neches River, and many tribal groups—including the Apache, Caddo, and Comanche—inhabited what is now Texas.

Conquest and Colonization. The first European explorers were the Spaniards Álvar Núñez Cabeza de Vaca (1528) and Francisco Coronado (1541). Other Spanish expeditions followed during the next century, and in 1682, Ysleta, near El Paso, became the first European settlement in Texas. Three years later Robert Cavalier, sieur de La Salle, brought the second flag (French) to Texas. He landed at the head of Lavaca Bay and established Fort Saint Louis. La Salle was killed by one of his own men in 1687, and his fort was destroyed by disease and the Indians. The Spanish soon increased their efforts to settle Texas, and by the middle of the 18th century they had mounted more than 100 expeditions to the area.

American Interest in Texas. The sale (1803) of Louisiana to the United States increased interest in Texas from the east. In 1819, Dr. James Long of Natchez, Miss., led an expedition to Texas, hoping to make the region an independent state. He captured Nacogdoches but his forces were soon defeated. A year later, Moses Austin visited San Antonio and sought permission to settle Americans in Texas. Upon returning to Missouri, his dying request was that his son, Stephen Austin, carry out his plans, which the Spanish had approved.

In 1821 the white population of Texas was 7,000, with Goliad, San Antonio, and Nacogdoches the only towns of any size. During this period Mexico secured its independence from Spain, and, in 1823, Stephen Austin went to Mexico City to seek confirmation of his father's grant. Austin made an agreement with the Mexican governor to settle 300 American families. Colonization was so successful, however, that by 1836 the population of Texas had grown to 50,000.

Revolution and Republic. Differences in language, culture, and religion soon led to difficulties between the new Anglo-American settlers and the Mexican government. Because of the great distance between Texas and Mexico City, cultural and commercial ties grew stronger with the United States.

In 1830 the Mexican congress enacted a law to limit immigration to Texas. But this only increased dissatisfaction, for neither the Mexican national constitution nor the constitution of 1827 for the state of Coahuila-Texas granted rights that Anglo-Americans considered inalienable, such as trial by jury and the right of bail. Most settlers also found unacceptable the requirement that they become Roman Catholics because most of them were Protestants.

War broke out between the American settlers and the Mexican government in 1835, and the Texans won the first battle at Gonzales on Oct. 2, 1835. The same year the Texans captured San Antonio; a provisional government was set up on Mar. 2, 1836, and Sam HOUSTON was named commander in chief of the Texas armies, Stephen Austin having gone to Washington to solicit aid from the U.S. government.

In March and April 1836 one of the most heroic battles in history occurred at the Alamo. The besieged Texas forces commanded by William B. TRAVIS had been reduced to 157. He appealed for help, and about 30 additional men from Gonzales broke through the lines of the Mexican general, Antonio SANTA ANNA. The 187 defenders, commanded by Travis, James BOWIE, and Davy CROCKETT, then held the Alamo for another 5 days before it fell. March also saw a massacre at Goliad, in which the outnumbered Texans, having surrendered after a battle on Coleto Creek, returned to Goliad only to be killed on the orders of Santa Anna.

Despite reverses the Texans declared their independence, and on Mar. 2, 1836, David Burnet was named provisional president. On the afternoon of April 21, Sam Houston's troops attacked while Santa Anna was having his siesta. Their battle cry was "Remember the Alamo; Remember Goliad." Santa Anna fled but was taken the next day and held prisoner for 6 months. (See TEXAS REVOLUTION.)

Statehood and the Mexican War. The Texas republic was soon struggling with Indian wars, raids by Mexican forces, and financial problems. In September 1836, Texans voted for annexation by the United States; approval by the U.S. Congress was delayed until 1845, however, because of the northern states' opposition to the extension of slavery. On Dec. 29, 1845, the U.S. Congress accepted the Texas state constitution, and Texas became the 28th state, with legal slavery.

The MEXICAN WAR between the United States and Mexico followed, and the first battle took place on the very day of statehood. The U.S. victory in that war established the Rio Grande as the border between Mexico and the United States. Texas, however, claimed all the territory from the mouth of the Rio Grande to its source in southern Colorado, a claim vigorously opposed by those who wished to exclude slavery from the territories newly acquired from Mexico. In 1850, as part of the COMPROMISE OF 1850, Texas relinquished its claim to half of what today is New Mexico and portions of Colorado, Wyoming, Oklahoma, and Kansas.

Texas withdrew from the Union on Feb. 1, 1861. Little fighting took place on Texas soil during the Civil War, the most important engagements being the capture and recapture of Galveston, the principal port.

Military rule following the Civil War was short-lived, but the state was inundated with CARPETBAGGERS. On Mar. 30, 1870, Texas was readmitted to the Union. Following the Civil War cattle ranching became increasingly important to the economy, and vast herds were driven to the railroad in Kansas over the CHISHOLM TRAIL.

Modern Era. When the 20th century began, about 3 million people lived in Texas, and agriculture dominated the economy. Then in 1901, Spindletop, the state's first great oil gusher, was discovered. Soon oil was found in virtually every part of the state, and the great east Texas oil field, discovered in 1930, helped lessen the impact of the Depression.

Racial segregation was a continuing issue throughout most of the 1950s and '60s, but by 1966, Texas ranked first among southern states in integrating its schools.

Politically prominent Texans in the 1960s, '70s, and '80s included President Lyndon B. JOHNSON, Congresswoman Barbara JORDAN, and President George BUSH. In 1987 the Texas legislature approved a landmark $5.7 billion tax increase, the largest by any state in U.S. history. Some critics claimed that it did not completely correct Texas's past reliance on oil-industry taxes at a time when the state was becoming more dependent on service industries.

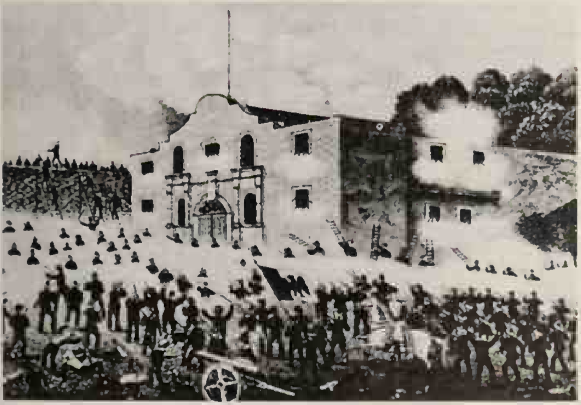
Texas, University of The University of Texas, governed by a board of regents and headed by a chancellor, is a coeducational state system of higher education that encompasses 15 campuses. The 4 major campuses within the system are located in Austin (founded 1881), Arlington (1895), El Paso (1913), and San Antonio (1969). Of these campuses, all but the campus at San Antonio offer bachelor's, master's, and doctorate degrees. The highest offering at the San Antonio campus is the master's degree. The University of Texas system also has 4 medical institutions—in Dallas, Galveston, Houston, and San Antonio.

Texas A&M University Texas A&M University, founded in 1876, is a public coeducational land-grant, space-grant, and sea-grant institution located in College Station, Tex. The university has colleges of liberal arts, science, engineering, agriculture and life sciences, veterinary medicine, education, geosciences, business administration, architecture, and medicine and a school of military sciences. It is part of the Texas A&M University system, which includes 8 campuses.

Texas Rangers The Texas Rangers originated in the 1820s as a volunteer corps to prevent Indian attacks and later became officers of the law; their exploits have become legendary. In 1835, the year before the Republic of Texas was born, the rangers became an official, full-time corps that was paid to defend the frontier. The United States annexed Texas in 1845 and protection of the frontier became a federal responsibility; the rangers then reverted to a volunteer, militialike organization. Under John Coffee (Jack) Hays, they fought in federal service during the Mexican War, winning national attention for their skill and bravery. Reorganized in 1874, the rangers—with the gradual end of the Indian wars—became a statewide law-enforcement agency responsible for suppressing feuds and riots, controlling cattle thefts, and capturing train robbers. Since 1935 they have operated as a branch of the Texas Department of Public Safety.

Texas Revolution In the Texas Revolution of 1835–36, American colonists in Texas secured the independence of that area from Mexico and subsequently established a republic. Since the 1820s many settlers from the United States had colonized Texas; by the 1830s they far outnumbered the Texas Mexicans. Mexican dictator Antonio López de SANTA ANNA attempted to reverse this trend by such measures as abolishing slavery and enforcing the collection of customs duties. The settlers rebelled and hostilities began at Gonzales on Oct. 2, 1835. The Texans repelled a Mexican force sent to disarm them and won subsequent victories.

In February 1836, Santa Anna led a large army across the Rio Grande but was delayed by the unexpectedly determined defense of the ALAMO. Meanwhile, the Texans declared their independence from Mexico on Mar. 2, 1836, and organized a provisional government. Sam HOUSTON led a successful retreat, but other insurgents were defeated and massacred in late March. Santa Anna pursued the rebels to the San Jacinto Prairie, but he was routed there on April 21 by Houston and taken prisoner. Mexican troops then withdrew from Texas. The Republic of Texas (with its Lone Star flag) remained independent until 1845, when it became part of the United States.



A Mexican army begins its assault of the Alamo, a former Spanish mission in San Antonio that was defended by a force of fewer than 200 Texas volunteers for 13 days in 1836.

textile industry The word *textile* (from the Latin *texere*, "to weave") originally meant a fabric made from woven fibers. Today the term signifies any of a vast number of fabrics produced by weaving, knitting, felting, and other techniques; it also refers to the enterprises that spin yarn from fiber or from synthetic materials and to the finishers and dyers of fabrics.

Chinese women prepare silk threads for weaving on a loom in this 17th-century woodcut. Sericulture, the raising of silkworms and the production of cloth from the fibers of their cocoons, has long been a vital economic activity throughout the Orient.

The Use of Natural Fibers. Until the 20th century all of the fibrous raw materials available for textile use were based on animal hair, plant or seed fibers, or the product of the silkworm. These are all organic fibers and are rapidly degraded by weathering or are destroyed by bacteria.

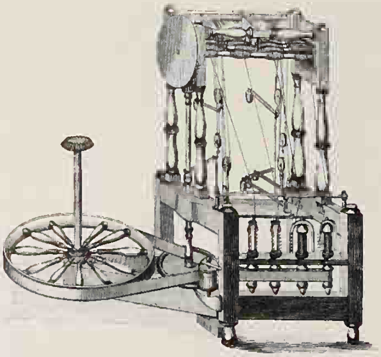
The earliest known samples of yarn and fabric of any kind were found near Robenhausen, Switzerland, where excavations unearthed 7,000-year-old bundles of flax fibers, yarns, and linen.

The cotton plant is indigenous to India, Egypt, and the warmer regions of the Americas; it was in these regions that the fiber was first used to make textiles. Cotton did not achieve commercial importance in Europe until after the colonization of the New World. Silk culture remained a specialty of the Chinese from its beginnings (*c.*2600 BC) until the 6th century AD, when silkworms were first raised in the Byzantine Empire. (See also FIBER, NATURAL.)

Synthetic Fibers. The desire to invent a fiber that resembled silk spurred the development of RAYON (1891), the first SYNTHETIC FIBER, and of its successors, NYLON (1939) and the various forms of polyester. Most synthetics are made by forcing a thick solution of polymerized chemicals through "spinneret" nozzles and hardening the resulting filament in a chemical bath (see PLASTICS).

Synthetic fibers have changed the textile industry radically. Their development has reduced world demand for natural fibers, and they have significantly broadened the area in which fibers are used—for example, as reinforcement in automobile tires.

Yarn Production. Silk is the only natural filament fiber, and it usually requires only the twisting together of several filaments to make a yarn. The other natural fibers must first be straightened and laid parallel by combing; then



The water-powered spinning machine patented in 1769 by Sir Richard Arkwright made it possible to produce an inexpensive all-cotton cloth for the first time. Arkwright's invention stimulated the development of the great English textile factories of the 18th and 19th centuries.

they must be drawn out into a continuous yarn by SPINNING. The spindle is the earliest spinning tool, and the spinning wheel (which first appeared in Europe about 1400) is its earliest mechanization. It was only during the late 18th century, with the invention (1767) of the spinning jenny, a machine that operated a number of spindles at one time, that yarn could be produced in appreciable volume. Richard Arkwright's spinning frame (1769) and Samuel Crompton's "mule" (1779) increased yarn production to the point at which one worker could operate 1,000 spindles at one time. Modern spinning machines are based on early-19th-century innovations, primarily the ring-spinning frame invented by the American John Sharp in 1828.

Fabric Production. The hand LOOM, in many variations, was for many centuries the basic WEAVING instrument. Mechanical improvements began to be developed in ancient times: the heddle, to which alternate warp threads are tied, was probably the first major innovation; the foot treadle, which could operate one or a series of heddles, followed shortly. Foot-powered looms with several sets of heddles appeared in Europe during the 13th century. Combined with the frame-mounted batten which was used to beat the weft, or filling yarns, into place, such looms were the principal types used in Europe for many years.

The first step in the creation of the modern loom was the invention by John Kay in 1733 of the flying shuttle, which allowed the weaver to send the shuttle across the width of the loom automatically. Edmund Cartwright devised the first steam-powered loom and, with James Watt, built (1785) the first steam-driven textile mill in England. Since that year innumerable improvements have been made in the power loom, beginning with the Jacquard (see JACQUARD, JOSEPH MARIE) punched-card system (1801), which provided the first successfully automated pattern weaving. Most modern looms are essentially high-speed versions of the early power looms, now made of steel instead of wood and operating almost entirely automatically.

Dyeing, Printing, and Finishing. Techniques of yarn and fabric dyeing have increased in complexity, especially since the 19th-century discovery of coal-tar DYES and the 20th-century development of synthetic fibers. Fabric printing came late to Europe (18th century) and was at first confined principally to block printing. (The SILK-SCREEN PRINTING process was developed for fabrics only during the mid-1800s.) Roller printing, using engraved copper rolls, was used first in England in 1785, followed in the same year by improvements that allowed roller printing in six colors, all in perfect register. Modern roller printing can produce in 1 minute 183 m (200 yd) of fabric printed in 16 or more colors.

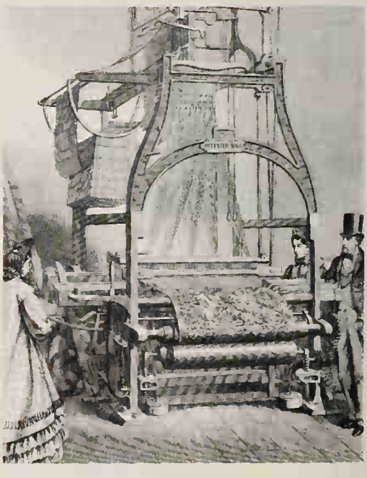
Modern finishing processes go far beyond the early processes, which were largely confined to shearing or brushing the nap of the fabric, to filling, or sizing, the cloth, and to passing it through calendar rolls to produce a glazed effect. Finishing today includes the preshrinking of cotton, wool, and rayon fabrics; mercerizing—treating cotton yarns and fabrics with caustic solutions to improve their strength and luster; and applying a number of different finishes that increase, among other things, crease resistance and water, flame, or mildew repellency. The properties of wash-and-wear fabrics often are obtained through finishing.

The Industry. Until the latter years of the 18th century the production of textiles was a handcraft, practiced in small units by skilled artisans and by cottage spinners and weavers. Large and economically vital cloth industries had emerged in Britain, Belgium, and other European countries. With the exception of the GOBELINS tapestry works in Paris, however, few factories in the contemporary sense existed.

The technical advances achieved during the 1700s, particularly in Britain, were the impetus not only for the establishment of the modern textile industry, but for the FACTORY SYSTEM and the INDUSTRIAL REVOLUTION as a whole.

Cloth had been made by American colonists since the building of a cloth "mill" in Massachusetts in 1638. The era of powered textile manufacturing, however, was inaugurated by an Englishman. Samuel SLATER, a former mill supervisor in England, rebuilt from memory a spinning frame in Providence, R.I., in 1790 and later founded several other mills.

Three years later Eli WHITNEY introduced his cotton gin, and the speed with which it could clean harvested cotton created a new demand for cotton fabrics. Factories



The Jacquard loom, developed in France in 1801, was the first machine capable of weaving figured patterns. The loom's weaving pattern was regulated by a chain of punched cards, a control mechanism similar to that used in early computers.

A printer aligns unfinished cloth under a mechanical silk-screen printer. Each screen acts as a stencil, applying a thick paint of a single color to form a portion of the final pattern.

sprang up throughout the eastern United States, particularly in New England. The perfection of a practical SEWING MACHINE during the mid-19th century increased the consumption of fabrics, and the American industry reached competitive status with its European counterparts.

After World War II the textile industry underwent significant changes throughout the world. Continuing a trend that had begun years earlier, much of the U.S. industry moved south from New England. New factories for the production of synthetic fiber were built almost exclusively in the southeastern and mid-Atlantic states. The cotton-spinning and weaving mills that had populated factory towns in Massachusetts and New Hampshire during the 19th and early 20th centuries closed one after another as the industry moved closer to energy sources and to lower-cost labor.

At the same time, textile manufacturing expanded overseas. Large textile establishments in China, Taiwan, Japan, and South Korea became competitive with American and European industry. Restrictive quotas and tariffs frequently have been imposed by countries that deem their industries threatened by foreign production. To counter the lower price of foreign textiles, the U.S. industry is becoming almost entirely automated. Computer-controlled technology has reduced labor needs and improved quality, as well as allowing manufacturers to make quick changes in the types of textiles they produce, in response to changing consumer preferences.

Tey, Josephine [tay] Josephine Tey was the pseudonym used by the Scottish writer Elizabeth Mackintosh, b. 1896, d. Feb. 13, 1952, to sign her eight well-known mystery novels, most of which feature Inspector Alan Grant. Mackintosh also wrote biographies, plays, and a novel, usually signing these works "Gordon Daviot"; but her Josephine Tey detective books provide the foundation for her continuing popularity. Alfred Hitchcock filmed *A Shilling for Candles* (1936) under the title *Young and Innocent* (1937). Other outstanding Tey works include *Miss Pym Disposes* (1946), *Brat Farrar* (1949), *The Daughter of Time* (1951), and *The Singing Sands* (1952).

Tezcatlipoca [tes-kaht-lee-poh'-kah] Tezcatlipoca was one of the most powerful gods worshiped in Aztec Mexico. He was among the creators of the Universe, ever young and virile, all-powerful and all-knowing. In his mirror of black volcanic glass he could see everything that happened in the world. He could transform himself at will into a jaguar or other animal. He was the god of darkness, the night sky, sorcery, and warfare, and the protector of the schools where young warriors were trained.

Thackeray, William Makepeace [thak'-uh-ree] A master of urbane irony, the British novelist William Makepeace Thackeray, b. Calcutta, July 18, 1811, d. Dec. 24, 1863, explored the moral and social pretensions of the Victorian age in his fiction.

Thackeray went to school in England and then traveled widely on the Continent. When he returned to London he began to write satirical magazine pieces. These include *The Yellowplush Correspondence* (1837–38), a view of high society through the eyes of a servant; *A Shabby Genteel Story* (1840); and *The Book of Snobs* (1846–48). *The Luck of Barry Lyndon* (1844), Thackeray's novel of this period, employs the 18th-century picaresque mode to chronicle the downfall of a handsome, socially ambitious rogue.

Thackeray's masterpiece, *Vanity Fair* (1847–48)—a panoramic novel ranging from the drawing rooms of London to the Battle of Waterloo—grew from his early works. Subtitled "a Novel without a Hero," *Vanity Fair* contains no character who exemplifies moral heroism. Instead, in concentrating on the amoral maneuvers of Becky Sharp in her drive for social position, Thackeray portrays an entire society that is, in his words, "living without God in the world," occupied only with the vanities of worldly advancement. This realistic, satiric novel was followed by *Pendennis* (1848–50), an account of a young man growing up that draws heavily on the author's own life. Thackeray subsequently turned to the historical novel with *Henry Esmond* (1852), a tale of political and religious in-

William Makepeace Thackeray, one of the most prominent British novelists of the Victorian age, is best known as the author of Vanity Fair *(1847–48). A successful lecturer, Thackeray published much of his work in periodicals, receiving acclaim for such satiric essays as those collected in* Roundabout Papers *(1860–63). (National Portrait Gallery, London.)*

trigue in 18th-century England. Its sequel, *The Virginians* (1857–59), continues the adventures of this family in America. Thackeray's interest in the 18th century also appears in his popular lectures on *The English Humourists of the Eighteenth Century* (1851) and *The Four Georges* (1855–60), both delivered during tours of the United States. Thackeray illustrated many of his own works, including *Vanity Fair*. His last major work was *The Newcomes* (1853–55), a rambling, often sentimental family saga. He died before he could finish his last novel, *Denis Duval*.

Thaddaeus, Saint [thad'-ee-uhs] Thaddaeus is mentioned in Mark 3:18 and Matthew 10:3 as one of Jesus Christ's original 12 apostles. He is often identified with the Jude, or Judas, son of James, in Luke 6:16. Although this identification helps reconcile the biblical lists of apostles, little is known of this minor figure. Feast day: Oct. 28 (Western); June 19 (Eastern).

Thai language see Sino-Tibetan languages

Thailand [ty'-land] The Kingdom of Thailand, located in Southeast Asia on the Gulf of Thailand and the Andaman Sea, shares boundaries with Burma on the west and northwest, Laos on the east and northeast, Cambodia on the southeast, and Malaysia on the south. Known also as Siam (before 1939 and from 1945 to 1949), the country was named Thailand, meaning "land of the free," in 1939. Thailand was never colonized by Europeans and has existed as a unified monarchy since 1350. The capital, Bangkok, was established in 1782.

Land and Resources

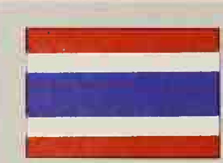
Thailand consists of a compact heartland, or mainland, and a long, southern peninsular extension of the Malay Peninsula. Forests occupy approximately 30% of the land area and farmland approximately 38%.

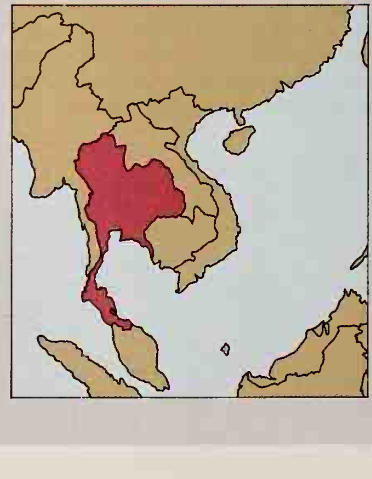
The central region, which occupies almost one-third of the nation and includes the fertile alluvial lowlands of the Chao Phraya, Thailand's "rice bowl," is the historical core of Thailand. Thailand's three other distinct topographical areas are the northern region, a mountainous, forested section that rises to Doi Inthanon (2,595 m/8,514 ft), the nation's highest peak; the northeastern, or Khorat Plateau, region, an area extremely poor in resources with unproductive lateritic soils; and the southern, or peninsular, region on the Malay Peninsula, rich in rubber and tin. The principal rivers are the Mekong, which follows much of the border with Laos; the Chao Phraya in the central region; and the Mun, a tributary of the Mekong in eastern Thailand.

A distinct dry season occurs from October to February, and a wet season from March to September. Rain is heaviest along the border with Burma, where about 5,590 mm (220 in) falls annually. Most of the Chao Phraya basin and the Khorat Plateau receive less than 1,522 mm (60 in). Temperatures range between 24° and 30° C (75°

AT A GLANCE

PRATHET THAI





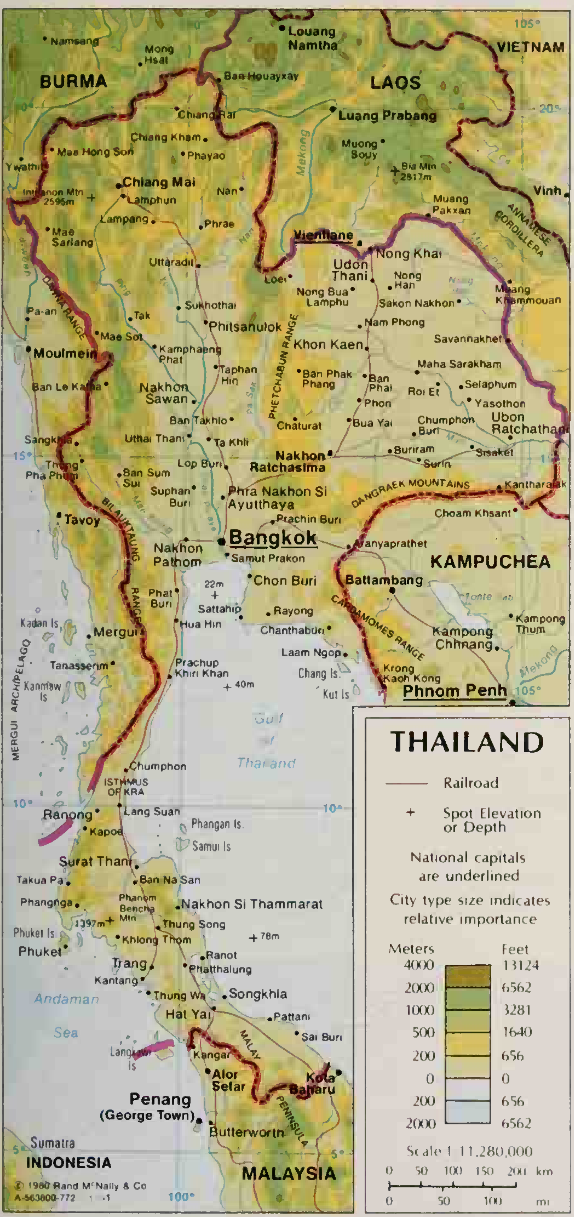
Land: Area: 513,115 km^2 (198,115 mi^2). Capital and largest city: Bangkok (1988 est. pop., 5,716,779).

People: Population (1990 est.): 55,115,683. Density: 107.4 persons per km^2 (278.2 per mi^2). Distribution (1990): 18% urban, 82% rural. Official language: Thai. Major religions: Buddhism, Islam.

Government: Type: constitutional monarchy. Legislature: National Assembly (suspended 1991). Political subdivisions: 7 regions.

Economy: GNP (1989): $69.95 billion; $1,238 per capita. Labor distribution (1990): agriculture—58%; commerce and services—10%; manufacturing—8%; government and public authorities—6%; construction—3%. Foreign trade (1990 est.): imports—$31.7 billion; exports—$23.3 billion. Currency: 1 baht = 100 satangs.

Education and Health: Literacy (1990): 70% of adult population. Universities and technical institutes (1988): 16. Hospital beds (1987): 88,262. Physicians (1987): 9,580. Life expectancy (1990): women—70; men—64. Infant mortality (1990): 34 per 1,000 live births.



and 86° F) throughout the year.

Thailand's fertile central plain regularly produces more rice than the nation requires. Thailand is also one of the world's largest producers of rubber. Its extensive rain forests also provide teak and other valuable hardwoods. Thailand has long been one of the world's most important producers of tin. Other minerals include tungsten, lead, fluorite, and lignite. Large deposits of natural gas are being developed offshore in the Gulf of Thailand.

People

Today Thailand has a population more than twice the 26,258,000 recorded in 1960. Ethnic Thai, or Siamese, make up about 75% of the population; ethnic Chinese, the largest minority, about 14%; and Malays, living mainly on the peninsula, about 4%. Scattered MON communities occur in the central region and Khmer and other "hill people" live in the northeast and along the border with Burma. Thai, which is not affiliated with any other Asian language, is spoken by approximately 97% of the population and is the official language. Theravada Buddhism, considered the national religion, is professed by about 95% of the population, although most Thai also traditionally believe that their lives are influenced by spirits and ghosts.

About 30% of the population live in the Chao Phraya basin, but even in the basin's densely settled delta region population densities are generally lower than in other Asian rice-growing nations. Bangkok is the largest urban area, followed by CHIANG MAI in the northern region.

Education has been compulsory for many years, and children between the ages of 7 and 14 are now required to attend school. Thai culture has its roots in Hinduism and Buddhism. Thailand's written literature dates from the 13th century, when the modern system of Thai writing was introduced. The golden age in Thai arts occurred during the 13th and 14th centuries and is reflected at its best in the many temples (*wats*) surviving from that period.

Economic Activity

Agriculture accounts for one-fourth of the gross national product. Rice, the principal crop and the leading export, is grown mainly in the Chao Phraya basin. Rubber, the second most important export, is produced in the southern peninsula. Plantation estates are generally small.

Manufacturing accounts for about one-fifth of the country's gross national product. The major industries are rice milling, tapioca clipping, and tin and petroleum refining, as well as the production of jute sacking, cotton textiles, clothing, footwear, refined sugar, cement, and tobacco. In addition, silk articles, jewelry, carved wood items, and cigarettes are produced in many homes, both in cities and villages.

Most traffic moves by water or along the nation's 3,855-km-long (2,395-mi) rail system radiating from Bangkok. Many roads are passable only in the dry season. The chief port is Bangkok. The principal exports are rice, rubber, and tin. Petroleum, machinery, and chemicals are the leading imports.

Government

Thailand is a constitutional monarchy, with the king exercising little power. The present monarch is King Bhumibol Adulyadej, who ascended the throne after his brother's death in 1946 and was crowned king in 1950. Constitutionally, power rests with the prime minister, a cabinet, and a bicameral legislature (National Assembly) composed of an appointed senate and elected house of representatives. In practice, however, the military has exerted great influence on civilian affairs, ruling the country intermittently after constitutional government began in 1932. A new constitution that came into effect on Dec. 9, 1991, granted increased rights to the military and was widely criticized as undemocratic. It was amended in June 1992 to require that future prime ministers be elected members of the legislature and to reduce the powers of the military-appointed Senate.

History

The history of Thailand before settlement by the Thais remains in dispute. Northeastern Thailand may have been the site of the earliest rice cultivation in Asia, and excavations in this region indicate that the metalsmiths of BAN CHIANG were working in bronze by the 2d millennium BC and possibly much earlier. The Funan Empire dominated after the 3d century, and the Mon kingdom of Dvaravati (*c.*550–1253), after *c.*675. Dvaravati became (11th century) a viceroyalty under the KHMER EMPIRE.

The Thais began migrating into the region from south China in the 11th century and established the kingdoms of Sukhothai and Chiang Mai. Sukhothai (1238–1419) overpowered Dvaravati by 1238 and, maintaining friendly relations with Chiang Mai, gained control by absorbing the Khmers. In the 14th century the Thai kingdom of Ayutthaya (1350–1767) subdued Sukhothai and other small kingdoms and became a regional center of wealth and power. Portuguese envoys arrived in 1511—the first Europeans to visit Siam.

Burmans destroyed the capital at Ayutthaya (AYUTIHIA) in 1767, and a new era, the Bangkok Period (1767–1932), began with the establishment of a new capital at Thon Buri, across the Chao Phraya from modern Bangkok. The present royal house is descended from General Chakkri, the second king of this period. In the 19th century King MONGKUT, or Rama IV (r. 1851–68), who ruled as an absolute monarch, began to modernize Thailand. His son CHULALONGKORN, or Rama V (r. 1868–1910), intensified the process by abolishing slavery and introducing railroads, telegraph services, and scientific education. This exposure to Western ideas culminated in a bloodless revolution by the Thai elite in 1932, who demanded a constitutional government limiting the powers of the king.

The revolution also began the struggle between military and civilian groups for control of the government, a continuing feature of Thai political life today. A civilian government under Seni Pramoj led the nation between 1945 and 1946 after the end of Japanese control in World War II. In 1947 a bloodless military coup brought Field Marshal Phibul Songgram to power, and a similar coup in 1957 replaced him with Field Marshal Sarit Thanarat. Sarit died in 1963, and his successor, Gen. (later Field Marshal) Thanom Kittikachorn, initiated a brief return to politically fractionalized civilian rule in 1968 but replaced it with martial rule in 1971 as unrest mounted. In 1973 an interim civilian government led by Sanya Dharmasakti was installed. Elections held in 1975 failed to produce a majority, and coalition governments led by Seni Pramoj and Kukrit Pramoj, respectively, both failed to unite the divided nation. Seni was reelected to office in 1976 but later that year was ousted in a military coup led by Admiral Saangad Chaloryoo. Thanin Kraivichien was named prime minister, but he was replaced in 1977 in a bloodless coup that brought Gen. Kriangsak Chomanan to power. Elections in 1979 returned Kriangsak to office as prime minister of an elected government, but he resigned in 1980. Gen. Prem Tinsulanonda, the new prime minister, remained in office following elections in 1981 and 1986. Prem unexpectedly declined another term after the 1988 elections. His successor, Chatichai Choonhaven, was ousted in a February 1991 coup led by Gen. Sunthorn Kongsompong. A nonelected military

Bangkok, the capital and principal metropolitan area of Thailand, has an attractive blend of Western and Thai architecture. The city is especially noted for its more than 400 temples, or wats, *of which Wat Arun (Temple of Dawn;* right*) is a famous example.*

prime minister was installed after elections under a new constitution in March 1992, sparking widespread protests. The army's brutal suppression of the demonstrations forced Sunthorn to resign, and the king appointed a transitional civilian prime minister. Prodemocracy parties won a slim majority in the September 1992 elections and formed a coalition civilian government headed by Prime Minister Chuan Leekpai.

Thailand, Gulf of The Gulf of Thailand (formerly the Gulf of Siam) is a shallow arm of the South China Sea with an area of about 238,000 km^2 (92,000 mi^2). The gulf is bordered by Thailand on the west and north and Cambodia and Vietnam on the east. The gulf is an important fishing ground and has many islands. Thailand's major port, Bangkok, is on the Chao Phraya River, about 50 km (30 mi) north of its mouth on the gulf.

Thales of Miletus [thay'-leez, my-lee'-tuhs] Thales of Miletus, *c.*636–*c.*546 BC, was the first known Greek philosopher and scientist. He achieved renown as a military advisor and engineer and is said to have predicted an eclipse of the Sun in 585 BC.

Thales apparently held that the Earth floats on water; all things come to be from water; and all things somehow consist of water. He manifests the tendencies, characteristic of early Greek philosophy, to treat questions of material composition and questions of material origin as the same question and to try to explain natural events by pointing to an underlying material element. He evidently chose water as that element due to its important role in the growth and nutrition of living things and in daily life. Thales is traditionally considered the teacher of ANAXIMANDER and the first figure in the MILESIAN SCHOOL of PRE-SOCRATIC PHILOSOPHY.

thalidomide [thuh-lid'-uh-myd] In 1961 the drug thalidomide, widely used to treat nausea and vomiting during pregnancy, was found to be associated with a syndrome of congenital malformations, particularly a severe handicapping abnormality of the arms. About 10,000 such children were born worldwide, with 5,000 in Germany alone. (Doubts concerning the drug's safety had prevented its sale in the United States.) The tragedy led to stringent governmental regulations for testing new drugs for teratogenic (malformation-inducing) hazards. Thalidomide continued to be manufactured in some countries, mainly for relief of leprosy symptoms. In the late 1980s it was being used successfully in clinical tests, in conjunction with cyclosporine, to treat graft-versus-host disease, a deadly immune reaction that affects nearly half the recipients of bone-marrow transplants.

thallium [thal'-ee-uhm] The chemical element thallium is a heavy metal with a physical resemblance to lead and a chemical resemblance to potassium. It is a member of Group IIIA in the PERIODIC TABLE. Its chemical symbol is Tl, its atomic number is 81, and its atomic weight is 204.37. Sir William Crookes of Great Britain first detected it spectroscopically in 1861 from the bright green color it imparts to flames. (The name derives from the Greek *thallos,* meaning "green" or "young twig.") The metal was isolated in 1862 by Crookes and independently by the French chemist Claude Auguste Lamy. Thallium is more abundant in the Earth's crust than mercury but is more widely dispersed. It is found principally in potash minerals and in zinc and lead sulfide ores.

Thallium is a soft, gray white metal (melting point 303° C, boiling point 1,453° C, density 11.8 g/cm^3). It forms compounds in two oxidation states, the more stable thallous (+1), which resembles potassium, and the strongly oxidizing thallic (+3), which behaves as aluminum. The metal dissolves in warm dilute mineral acids, forming thallous salts and liberating hydrogen gas. Extremely toxic, thallium compounds are restricted to unique applications: specialized photocells, certain optical glasses, and low-freezing liquid mercury-thallium alloys for stratospheric and arctic thermometers. Thallous sulfate was formerly widely used as a rat and insect poison.

Thames, River [temz] The Thames is a river in southern England, rising in the Cotswold Hills of Gloucestershire and flowing east, through London, to its estuary on the North Sea. The river is 248 km (154 mi) long from its source at Thameshead to London Bridge, from which it flows an additional 90 km (56 mi) to the open sea. The Goring Gap near Reading divides the upper river basin from the lower. London lies at the lowest bridging point on the river. The Thames, England's principal river, has many tributaries: the Churn, Coln, Windrush, Evenlode, Cherwell, Ock, Thame, Kennet, Loddon, Colne, Wey, Mole, and Medway.

The river's flow varies with the seasons and is greatest in winter, when the land along its banks is subject to flooding. The tide ascends to Teddington Lock, about 30 km (20 mi) upstream from London Bridge. Because of the danger of inundation by sea surges along the lower river, a 0.52-km-wide (0.32-mi) movable flood barrier was constructed at Woolwich. It became operational in 1982 and was dedicated in 1984. The freshwater Thames serves as the chief water supply for London, its western suburbs, and areas around Oxford.

Thanatos [than'-uh-tahs] In Greek mythology Thanatos was the god of death. He dwelt with his brother Hypnos (Sleep) in the underworld and is portrayed as winged, bearded, and holding a sword. He was said to be the only god who shunned sacrificial offerings.

Thanksgiving Day Thanksgiving is an annual holiday celebrated in the United States on the fourth Thursday in November. The first Thanksgiving, three days of prayer and feasting, was celebrated by the Plymouth colonists in 1621 to give thanks for their first harvest and for surviving the first terrible Massachusetts winter. The first national Thanksgiving Day, proclaimed by President George Washington, was celebrated on Nov. 26, 1789. In 1863, President Abraham Lincoln made Thanksgiving an annual holiday to be commemorated on the last Thursday in November. For 3 years (1939–41) under President Franklin D. Roosevelt, the day was celebrated on the third Thursday in November, but it was returned to the fourth November Thursday by Congress in 1941.

In Canada, Thanksgiving, first observed in November 1879, is officially celebrated on the second Monday in October.

Thant, U [thahnt, oo] The Burmese educator-diplomat U Thant, b. Jan. 22, 1909, d. Nov. 25, 1974, was the first Asian secretary general of the United Nations. Thant was educated at the University of Rangoon and served (1953–57) as secretary to U Nu, the first premier of independent Burma.

In 1957, Thant was named Burma's permanent representative to the United Nations (UN). Four years later, when Dag Hammarskjöld was killed in a plane crash, Thant became acting UN secretary general. Elected to the position in 1962, he continued in office until his retirement in 1971. Thant was involved in the settlement of many international crises, including the Cuban Missile Crisis (1962), the Congo Crisis (1963), the civil war in Cyprus (1964), and the India-Pakistan War (1965).

Thar Desert [tahr] The Thar, or Great Indian, Desert is located in northwestern India and southeastern Pakistan. The desert has an approximate area of 250,000 km^2 (97,000 mi^2). It is bordered on the west by the Indus River, on the east by the Aravalli Range, on the north by the Punjab plain and the Sutlej River, and on the south by the Rann of Kutch. Annual rainfall varies between 100 mm (4 in) in the west and 500 mm (20 in) in the east. Much of the Thar consists of shifting dunes and exposed resistant sandstone. Wheat and cotton are grown on the irrigated Indus plain in the northeast, and nomads raise sheep, cattle, and camels. Coal, gypsum, and limestone are mined, and salt is taken from saline lakes.

Tharp, Twyla [thahrp, twy'-luh] Twyla Tharp, b. Portland, Ind., July 1, 1941, is a provocative and controversial choreographer who, since the early 1970s, has developed a uniquely original movement style based on ballet, tap, black-jazz, and social dance forms. Her style is at once both casual and rigorous, pop and high art. Tharp danced (1963–65) with the Paul Taylor Dance Company before forming her own group. Her *Deuce Coupe*, created for the Joffrey Ballet in 1973, brought her nationwide attention. For American Ballet Theatre (ABT), she choreographed both *Push Comes to Shove* (1976), the first American work created for Mikhail BARYSHNIKOV, and *Bach Partita* (1983), her first full-scale classical ballet. Tharp joined ABT as a resident choreographer in 1988. She also has choreographed several films.

Thatcher, Margaret [thach'-ur] Margaret Hilda Thatcher, b. Oct. 13, 1925, Britain's first woman prime minister and the longest-serving British prime minister of the 20th century, reshaped the image of her country's Conservative party. Born Margaret Roberts in Grantham, Lincolnshire, she married Denis Thatcher, a businessman, in 1951. A Conservative party activist since her school days, she was elected to the House of Commons in 1959 and entered Edward Heath's shadow cabinet in 1967. Thatcher served under Heath as secretary of state for education and science from 1970 to 1974; then challenged him for the party leadership in 1975 and won, becoming the first woman to lead a major British party.

Vigorously attacking the Labour government of James Callaghan and profiting from public dissatisfaction with labor unrest, she led the Conservatives to a 44-seat majority in the general election of May 1979 and formed her first government. She won a second electoral victory with a majority of 144 in 1983, and a third with a 101-seat majority in 1987.

Proud of her middle-class, NONCONFORMIST, small-town background, Thatcher extolled the virtues of freedom, hard work, thrift, and personal responsibility and had a strong dislike for socialism. As prime minister she rejected the welfare-state policies followed for decades by both Labourites and Conservatives, promoting a free-enterprise economy, tight monetary policies to control inflation, lower taxes, reduced government spending, privatization of nationalized industries and public housing, and restrictions on trade unions. Firmly committed to the Western alliance, she strengthened British defenses and had close ties with U.S. presidents Ronald Reagan and George Bush. In 1982 she successfully pursued a war with Argentina over the FALKLAND ISLANDS.

Early in 1990, Thatcher created a furor with her unpopular community charge or "poll tax," levied equally on all citizens for the support of local government. In the fall

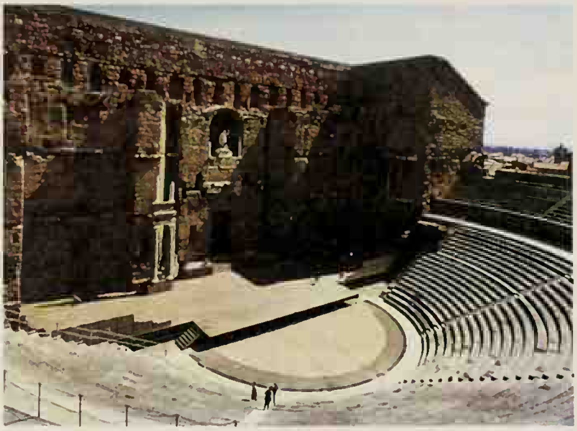
Margaret Thatcher waves to reporters while campaigning prior to Britain's 1979 general elections. Speaking out against Britain's "slither and slide toward the socialist state," Thatcher led her Conservative party to a decisive victory. Her government was reelected in 1983 and 1987, making her the first British premier to win three successive elections in more than 150 years.

she provoked a rebellion in her own party because of her opposition to full British participation in a European monetary system. Forced to resign as prime minister and party leader in November 1990, she was succeeded by her chancellor of the exchequer, John Major.

theater, history of the Theater (from the Greek verb *theasthai*, "to view" or "to see," whence *theatron*, or "seeing place") may be defined not only as a structure in which dramatic performances are given, but as the sum of all the arts required for the production of a dramatic, or imitative, action. These include acting, directing, stage lighting, theater architecture, theater costume and make-up, machinery and special effects, and dramaturgy or playwriting (see drama). Other mimetic performing arts, such as opera and ballet, are closely related to the theater. The following essay focuses on the evolution of the theater in different periods and cultures.

Origins of the Theater. The theater originated in the cultures of primitive societies, whose members, it is thought, used imitative dances to propitiate supernatural powers. A shaman, priest, or medicine man (in effect, the first director) taught complicated dance steps and led these ritual dance-dramas—to ensure the Earth's fertility, to expel evil spirits that caused disease, and to force the souls of the newly dead to depart the world of the living. The priests and performers in these dance-dramas wore masks, which sometimes represented the spirits invoked. As knowledge of natural phenomena increased, drama ceased to be exclusively ritualistic and also became an educational tool, especially in initiation ceremonies that acquainted the young with tribal culture. A later development was the enactment of legends of gods and tribal heroes. Such dramas were also performed in early civilized societies. In Egypt, for example, dramas dealing with the god Osiris continued to be produced until at least as late as the 5th century BC.

A 1st-century AD relief from a private house in Pompeii depicts masked actors performing in a comedy. The theatrical traditions of ancient Greece, widely adopted by the Romans, included the wearing of masks. (Museo Nazionale, Naples.)



The Roman theater in Orange, France, is typical of the theaters built during the Imperial era. Many of its features would later be copied by Italian Renaissance architects, especially the low raised stage and the permanent architectural facade.

Classical Greek and Roman Theater. The history of European theater begins with the Greeks, whose annual festivals in honor of the god Dionysus included competitions in tragedy and comedy. According to tradition, the first of these dramatic forms evolved from choral songs (choric dithyrambs) concerning the death and resurrection of Dionysus. This occurred about the middle of the 6th century BC, when Thespis of Icaria, in a drama of his own composition, impersonated a character and engaged the chorus in dialogue, thereby becoming both the first playwright and the first actor. Thespis won first prize in the initial tragedy competition held at Athens in 534 BC and is also credited with the introduction of masks, which were thereafter a conventional feature of Greek and Roman theater. The tragedians Aeschylus and Sophocles later added a second and a third actor to tragedy, and about the beginning of the 5th century BC comedy was given written form by Epicharmus of Syracuse and was also admitted to the festivals. The ancient chorus was retained as an integral part of Greek drama and eventually consisted of a standard number of members: 15 in tragedy and 24 in comedy. In a satyr play, a short burlesque that dramatists were expected to submit along with their tragedies, the chorus comprised either 12 or 15 members. All of the roles were played by men; women were not allowed to perform in the Greek theater.

The early Greek playwrights not only wrote and frequently acted in their plays but also served as directors and choreographers; some may also have composed their own music (Greek tragedy was intensely musical). Sophocles is said to have been a scene designer and Aeschylus to have invented the tragic costume. Tragic actors wore a tight-sleeved, belted, patterned tunic called a chiton; a variety of cloaks over the chiton; the cothurnus, or tragedian's boot, which in later periods became exaggeratedly elevated by the addition of a wooden platform to the sole; and the helmetlike mask with attached wig, in which the forehead elevation was proportional to the social status of the character represented. Characters in Old Comedy were usually costumed in short chitons heavily padded in front and behind and wore grotesque masks and stuffed phalluses. With the arrival of New Comedy in the later 4th century BC these features were discarded and comic characters became more respectably dressed.

The original Greek theater at Athens was simply a large circle known as the *orchēstra* ("dancing place"); spectators sat on seats set into the southern slope of the Acropolis. It was not until about 460 BC that a *skené*, or stage building, was added at the rear of the orchestra. The actors then made their entrances and exits through this structure, although the acting was still confined to the flat orchestra. A limited amount of scenery, painted on panels attached to the *skené*, may have been used at this time. Special effects included the *eccyclema*, or "wheeling out" machine, a wagon or perhaps a turntable on which tableaux were displayed, and a crane by which actors representing gods could be flown above the stage. The playwright EURIPIDES was fond of both these devices, and his contemporary ARISTOPHANES ridiculed his use of them in several of his comedies.

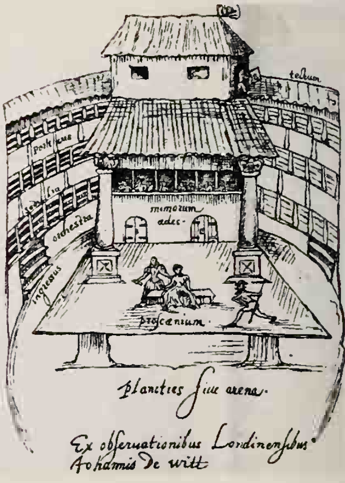
By the 4th century BC the Greek theater had become a professional institution with specialists responsible for the various aspects of theatrical art. In the next two centuries, during the Hellenistic Age, the physical structure of the theater continued to evolve, the most notable innovation being the addition of a raised stage (*logeion* or "speaking place"). The Romans, whose capital did not possess a permanent theater until 55 BC, also staged their productions on a raised stage before an elaborately decorated stage building and reduced the orchestra, as well as the auditorium, to a semicircle. They built freestanding structures that could be covered by huge awnings and are reputed to have seated as many as 40,000 spectators. Both tragedy and comedy—almost entirely derived from Greek models—were performed, as well as a Roman innovation, pantomime (see MIME AND PANTOMIME), in which a single actor, frequently changing masks and accompanied by a large chorus and orchestra, mimed and danced all the roles in the drama.

Although early Roman actors were often slaves owned by managers, later actors like Claudius Aesopus, Roscius, and the pantomimists Pylades and Bathyllus—all of whom flourished in the 1st century BC—were citizens and attained considerable fame and fortune.

Medieval Theater. The early Christians denounced the theater as the "shrine of Venus" (an allusion to the prostitutes who frequented the Roman theater, as well as to its pagan origins) and objected to its parodies of Christian sacraments. Consequently, a barrage of church decrees was directed against the theater and anyone patronizing it, and by the end of the 7th century theatrical entertainments had been extinguished in both the western and eastern Roman Empire. Yet, paradoxically, the church was also responsible for the rebirth of the theater during the Middle Ages, when dramatic performances based on the story of the Resurrection were introduced into the Easter service (see MEDIEVAL DRAMA). From these little tropes, originally performed by monks and priests, arose the great cycles of mystery plays that dramatized virtually every phase of biblical history. Produced by the various guilds and lay religious brotherhoods, and sometimes by entire communities, these vast cycles occasionally took as many as 25 or even 40 days to perform. The acting, primarily by amateurs, was realistic, as were the theatrical tricks that included such spectacular effects as flames and smoke belching from Hellmouth, floods of water, massacres with flowing blood, and hangings and crucifixions that often posed serious hazards for the actors. The directors were also usually amateurs, although a few were professionals who traveled from city to city.

The Renaissance. By the mid-16th century the medieval religious theater was in decline, to be succeeded by a revival of secular drama performed by professional acting companies. In England such troupes had been attached to the households of noblemen and the king since the 15th century. At first they performed in halls and inns but eventually in theaters of their own, the first of which—named "The Theatre"—was erected on the outskirts of London in 1576. Other ELIZABETHAN PLAYHOUSES, including the Curtain, the Rose, and the famous Globe Theater, followed soon after. In general these theaters were circular or polygonal structures, consisting of a three-story "frame" surrounding an open-air yard. Spectators sat in boxes or galleries within the frame or stood below in the yard, a large portion of which was occupied by a platform stage that was partially protected by a "shadow" or roof. At the rear of the stage was the "tiring house," where the actors dressed and stored their properties. The actors' costumes, mainly contemporary and only rarely attempting historical accuracy, were often sumptuous and represented an investment second only to the expense of the playhouse.

Elizabethan actors—all of whom were male—were organized under the guild system of masters, journeymen, and apprentices. These troupes were known by the titles of the noblemen or members of the royal family who were their patrons. Thus William SHAKESPEARE and the actor Richard BURBAGE, the original interpreter of Hamlet, Othel-



A contemporary copy of Johann de Witt's sketch (c. 1596) of the Swan Theatre shows a typical Elizabethan playhouse. The yard, or pit, surrounded the stage, and it was here that most of the audience stood. To the rear of the stage was the tiring house, surmounted by the hut, from which special effects were produced.

The Royal Theater in Turin, designed by architect Benedetto Alfieri, was built in 1738. The theater was renowned for its acoustics and for its commodious orchestra pit. Like most European theaters of the time, it presented operas as often as dramas. (Museo Civico, Turin.)

lo, and Richard III, were both members of the Lord CHAMBERLAIN'S MEN, who in 1603 came under the patronage of the king and thereafter were known as the King's Men; while their contemporary Edward Alleyn, who performed the leading roles in the plays of Christopher MARLOWE, was a member of the rival Lord Admiral's Men, later Prince Henry's Men. Those master actors who pooled their resources to erect the theaters and purchase the costumes and properties required by their companies were also known as "sharers." The sharers or managers also bought plays outright from dramatists, who were not entitled to royalties or any additional payments if their works were published. Besides performing in the large public playhouses, Elizabethan actors frequently took their productions to court and, during the winter months, appeared in smaller indoor houses known as "private" theaters.

In Spain, where professional actors, led by such legendary figures as Lope de Rueda, also came into their own in the 16th century, the public theaters were owned by religious brotherhoods and municipal governments. Set up in *corrales*, or large yards between houses, such theaters were similar to those in England. In Spain, as in England, all roles were portrayed by males, a convention that persisted until 1587. The actors were under contract to managers, known as *autores de comedias*, who purchased costumes and plays and hired out their troupes to the lessees of the *corrales*. The companies were also engaged to perform at annual religious festivals and, especially during the 17th century, at the Spanish court, where productions were heavily influenced by Italian staging practices. During this period, too, Spanish drama experienced its golden age, with such prolific playwrights as Lope de VEGA and Pedro CALDERÓN DE LA BARCA writing hundreds of plays.

It was in Renaissance Italy that the theater first broke definitively with the medieval tradition. Inspired by descriptions of the ancient Roman theater in the writings of VITRUVIUS and other Latin authors, the Italian humanists (see HUMANISM) deliberately set out to re-create its structure, an endeavor that culminated in the Teatro Olimpico at Vicenza, designed by the architect Andrea PALLADIO and opened in 1585.

From their reading, the humanists also learned that the Greeks and Romans had occasionally used illusionistic paintings on their stages and had devised three-sided revolving prisms (*periaktoi*) to change such scenery—descriptions which led, as early as 1508, to the use of unified, perspective settings and, shortly afterward, to experiments with *periaktoi* and other methods of changing scenery before the eyes of the audience. A proscenium frame and front curtain then came into use, as did a variety of flying machines and special effects. Because the majority of Renaissance theaters were indoor structures, lighting—supplied by candles and oil lamps—also became an important consideration.

The actors in the early Italian theater were usually amateurs. By the mid-16th century, however, they had been supplanted to a great extent by the professional players of the COMMEDIA DELL'ARTE who, in addition to the improvised comedies for which they were famous, were equally at home in literary and musical drama. A notable feature of these companies is that from their inception some seem to have included women. The beautiful Isabella Andreini (1562–1604), who belonged to the troupe known as the Gelosi, was the most celebrated actress of her day and was also a gifted dramatist and poet.

Because the *commedia* players traveled widely and were extremely popular outside Italy, they exerted considerable influence on the theaters of other nations. Their appearance in 16th-century Spain, for example, led to the admission of women to the Spanish companies, and in Paris, where they were known as La *Comédie Italienne*, they were even given a theater of their own.

Baroque and Eighteenth-Century Theater. By the early 17th century the Italian theater had given rise to the architectural structure and staging conventions that, with minor variations, have remained in use to the present day. The auditorium itself, as evidenced in opera houses built at Venice and elsewhere, had evolved into a bench-filled "orchestra," or parterre area, before the stage and a series

Two figures from the commedia dell'arte cavort in a painted copy of an etching by Jacques Callot. His commedia sketches (1621) convey the zany, bawdy, dance-and-mime character of this early theatrical genre. (Museo Teatrale, Milan.)

of galleries divided into boxes at the sides and rear of the house. The stage, separated from the auditorium by the familiar proscenium, or "picture frame," was decorated with perspective settings painted on flats, which could easily be changed either by hand or, through a later invention of the designer Giacomo Torelli (1608–78), by an ingenious mechanical system of chariots, ropes, and counterweights. Similar architectural structures and scenic practices were soon adopted throughout Europe.

The admission of women to both French and English acting companies began during the 17th century. In England, following the accession of Charles II in 1660, the earlier convention of using boy apprentices for female roles was abandoned, and such actresses as Elizabeth Barry and Anne Bracegirdle appeared in the plays of Thomas Otway and William Congreve. In France the former acrobat Thérèse du Parc, after starting with MOLIÈRE's troupe, became a leading tragedienne in the plays of Jean RACINE and was followed by the actress known as La Champmeslé, who in 1677 created the title role in Racine's *Phèdre* and later became the first leading tragedienne at La COMÉDIE FRANÇAISE. In addition to salaries or, in some cases, shares in the companies' profits, actors were granted "benefits"—performances from which they were entitled to the profits after the house expenses had been deducted. Playwrights retained the right to publish their works. As yet there was no professional director, the duties of this office usually falling to one of the principal actors and sometimes to the dramatist. Molière, who was an actor as well as a playwright, directed the members of his company, and Racine coached the actors in his plays.

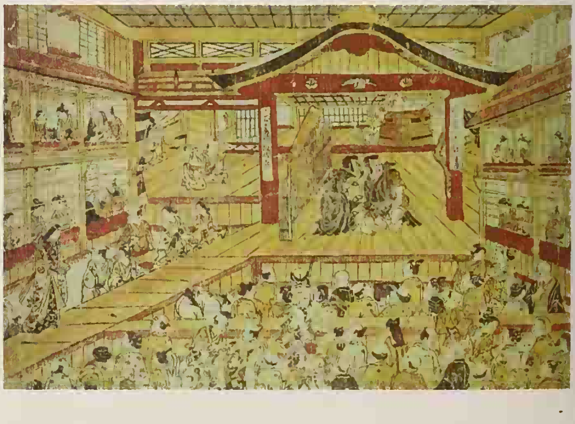
By the early 18th century a few individuals, like the English playwright Aaron Hill, were urging reform in costume and scenic practices. David GARRICK, possibly the finest actor of the century, attempted historically accurate productions while managing the DRURY LANE THEATRE in London from 1747 to 1776. In France, actors such as Hippolyte Clairon and the director of the Opéra Comique, Charles Simon Favart, initiated similar reforms at their theaters. In general, however, it was not until the 19th century that it became customary to create historically accurate costumes and settings for individual productions.

Meanwhile, the American colonial theater—supplied with English actors, English plays, and following English stage practices—had taken its first tentative steps, and in Germany, where English and French influences had dominated during the 16th and 17th centuries, native actors and playwrights had at last come into their own. Spurred on by such figures as Konrad Ekhof (1720–78), known as the father of German acting, and Gotthold Ephraim LESSING, the first German playwright of distinction, both court and municipal theaters experienced a period of unprecedented growth and support by the aristocracy and the emerging middle class. There shortly followed the revolutionary STURM UND DRANG school of drama. At the court theater of Weimar, under the artistic management of Johann Wolfgang von GOETHE during the period 1791–1817, a distinctive style of ensemble acting and unified production known as Weimar Classicism evolved. The actors (and sometimes even the audiences) were carefully disciplined by the autocratic director; costumes and settings were based on historical research; and the plays of Goethe and of his friend Johann Christoph Friedrich von SCHILLER were splendidly produced. The 18th century was also the last great age of aristocratic theater, particularly in France and the Germanic countries.

Oriental Theater. Although it exerted relatively little influence on Western theater, the theater of the Orient has an equally long and illustrious history. Its origins also appear to have been in ritualistic dance-dramas, and to this day dance and music play an important role in the Oriental theater. In the West the theater has most often followed a realistic style of presentation, but the theater of the East remains intensely symbolic, requiring considerable sophistication on the part of its viewers. The actors appear in masks or wear highly artificial, masklike makeup whose appearance and colors indicate the characters' social status and qualities. The design and colors of costumes are equally symbolic; movements and gestures, each of which carries a precise meaning, are carefully choreographed and codified; speech is artificial and often musical; scenery and stage properties are minimal.

The earliest Oriental theaters are believed to have been in India, where Sanskrit dramas were produced in temples and at court several centuries before the birth of Christ. The acting area seems to have been a raised platform before a curtain; in place of scenery the actors or a narrator set the stage with dialogue and pantomime. In China, where the distinctive form of theater known as Beijing Opera evolved at the end of the 18th century, the stage was originally a roofed platform with two doors at the rear. Stagehands, dressed in black and by convention understood to be invisible, manipulated properties while the drama was in progress. Female roles, at least until recently, were undertaken by males; the actor MEI LANFANG, who also performed in the West, was the outstanding interpreter of women in the 20th century.

The Japanese Kabuki theater encourages intimacy between actors and audience, who are in close contact as the actors move along the hanamichi, *or walkway, that connects the stage with the rear of the theater. The walkway is used for entrances and exits, and as an auxiliary stage.*



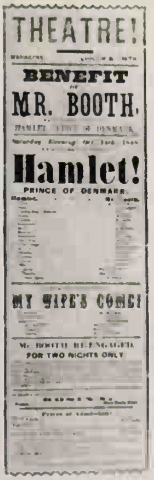
More familiar to contemporary Western audiences is the theater of Japan, where three indigenous forms—No drama, Bunraku, and Kabuki—are still produced. The No theater originated in the 14th century and was initially given before aristocratic and priestly audiences. The masked actors are exclusively male. In Bunraku, all of the actors are puppets, each of whose complicated movements require no less than three expert handlers. It was for this theater that Chikamatsu Monzaemon, the most famous of Japanese playwrights, wrote many of his later dramas.

The popular Kabuki theater began in the 17th century and borrowed many elements from No and Bunraku. This form of theater, in which dance plays a prominent role and the actors appear in exaggerated makeup, is more realistic in its scenic practices. Traps are used to raise and lower actors and scenery, and in the 18th century rapid shifts of setting became possible with the introduction of the revolving stage—a feature eventually adopted by Western theater.

Another well-known form of Oriental theater, the shadow puppet plays still performed in Indonesia, may have originated in India or China. Toward the end of the 18th century, when they were known as *ombres chinoises* (see shadow play), these plays were introduced to Paris and later, in the 1790s, were shown in London.

Nineteenth-Century Theater. At the close of the 18th century a host of new theaters appeared to cater to the tastes of working-class audiences who delighted in pantomimes, spectacles, vaudevilles (see music hall, vaudeville, and burlesque), and melodrama. On a somewhat higher plane romantic drama and revivals of the classics, produced at the major theaters, were performed by such notable actors as François Joseph Talma, Mademoiselles Mars and Duchenois, and Rachel, the famous interpreter of Racine's *Phèdre,* in France; John Philip Kemble (see Kemble family) and his sister Sarah Siddons, Edmund Kean (see Kean family), and William Charles Macready were the reigning stars in England. In the United States, which continued to be heavily dependent on Europe for its drama and theater practices during most of the 19th century, the first native actors to achieve international reputations now appeared: the African-American tragedian Ira Aldridge, the brawny Edwin Forrest, and Edwin Booth (see Booth family), who also managed his own theater in New York City.

By the 1820s gas had replaced candles and oil lamps in many theaters; limelight and the carbon arc for spotlighting effects were in common use by the mid-century; and in 1881, with the opening of the Savoy Theatre in London, the stage was first lit by electricity. Stages became fully trapped (a few, like Booth's New York theater, had hydraulic lifts), and scenery could be raised from below or "flown in" from above the stage. Settings, properties, and costumes attained maximum realism and histor-



THEATRE!

BENEFIT

MR. BOOTH.

Hamlet!

PRINCE OF DENMARK.

MY WIFE'S COME!

FOR TWO NIGHTS ONLY

(Left) *Edwin Booth, the most popular U.S. actor of the last half of the 19th century, is shown here as Hamlet, his most famous role. The 1848 playbill for a St. Louis theater advertises his father, the English actor Junius Brutus Booth, Sr., in the same role.*

France's great actress Sarah Bernhardt found the equal to her exotic flamboyance in the art of Alfons Mucha. His first Bernhardt poster, for the play Gismonda *(1894), made his name in Paris, and he continued to produce not only posters but also costume and jewelry designs for the Divine Sarah—including this advertisement for the actress as the anguished, revenge-seeking heroine of Corneille's* Médée.

ical accuracy. The "long run" became increasingly common, and the older repertory system—under which theaters had changed their bills almost nightly and a single house might present dozens of new and old plays in a single season—was gradually abandoned.

Concurrent with the rise of elaborately planned productions was the arrival of the modern director, who might still be a leading actor, but was responsible for overseeing every aspect of production and for imposing a unity on the whole. This arrangement also encouraged an ensemble style of acting, in which the actors blended their talents and none starred at the expense of others—or of the play itself. Among the earliest of this new breed in England were the actress, dancer, and singer Madame VESTRIS, who produced comedies and extravaganzas at her elegant little theater, the Olympic, in the 1830s, and in the 1850s, Charles Kean, son of Edmund, who was celebrated for his Shakespearean productions at the Princess's Theatre. Kean was especially noted for his skillful handling of crowd scenes and exerted a profound influence on George II, duke of SAXE-MEININGEN, whose own company of German actors toured throughout Europe in the 1870s and 1880s and in turn directly influenced such later directors as André Antoine and Konstantin STANISLAVSKY. The principles of this style of production—sometimes referred to as the "theater of the *régisseur* (director)"—are still widely followed, although most present-day directors do not act in their productions.

The status of the playwright also improved during the 19th century. At the urging of dramatists such as Dion BOUCICAULT, who also directed and acted in his popular plays on both sides of the Atlantic, COPYRIGHT laws were enacted to protect authors' rights, and dramatists now became entitled to royalties.

Seeking to give a truer depiction of life, a number of playwrights—Émile ZOLA, Henrik IBSEN, and Gerhardt HAUPTMANN among them—founded the naturalistic school of drama. Because their controversial works were forbidden in the commercial theaters of most countries, it became necessary to establish subscription theaters, which were nominally private and thus beyond the control of official censors. From this necessity sprang the Independent Theater movement, the first of whose theaters, the Théâtre Libre in Paris, was founded by André Antoine in 1887. Die freie Bühne in Berlin and the Independent Theater (1891) in London followed a few years later. As even newer schools of drama appeared on the scene, playwrights continued to find outlets for their works in theaters that pursued artistic rather than commercial objectives. In 1898 the Moscow ART THEATER—famous above all for its productions of Anton CHEKHOV—was founded by Konstantin Stanislavsky and Vladimir Ivanovich NEMIROVICH-DANCHENKO, and in 1907 the expressionist author August STRINDBERG opened the Intima Teatern in Stockholm, where he presented his own plays. Meanwhile, even the classical repertory was undergoing an intensive reevaluation. In 1894 the English director William Poel founded the Elizabethan Stage Society, whose productions of Shakespeare and other Elizabethan dramatists broke with the 19th-century tradition of realistic staging and attempted to re-create the conventions and architectural arrangements of Shakespeare's day—an approach that is still followed at numerous Shakespeare festival theaters.

Twentieth-Century Theater. At the turn of the 19th century a number of designers were also calling for a break with older traditions. Both Gordon CRAIG and Adolphe Appia argued for settings and lighting that were suggestive and expressive of the mood of the drama rather than realistic. Their ideas have influenced many later theater artists—in the United States the most eminent has been Robert Edmond JONES—although no particular school of design can be said to predominate at the present day. Indeed, 20th-century stage designs have included both the most elaborately detailed naturalistic settings and stages devoid of anything but a few essential properties, not to mention the bizarre constructivist (see CONSTRUCTIVISM) settings created in the 1920s for the Russian director Vsevolod Emilievich MEYERHOLD, who expected his actors to physicalize their emotions and to perform within playgroundlike settings as gymnasts and acrobats. The Italianate proscenium-frame stage—an object of scorn to avant-garde directors—remains entrenched in the majority of theaters, but the Renaissance acting platform has reemerged as the "thrust stage," and a few experimental

The first production of Chekhov's Uncle Vanya *(shown here, a scene from act 4) was staged at the Moscow Art Theater in October 1899, directed by Konstantin Stanislavsky and Vladimir Nemirovich-Danchenko. Their theatrical goal—in Stanislavsky's words, to convey "the inner truth, the truth of feeling and experience"—was achieved by their actors through intense study and many long rehearsals. Their productions were notable as well for the scrupulous realism of settings and effects.*

(Left) *The original production of Arthur Miller's Pulitzer Prize-winning play,* Death of a Salesman, *starred Mildred Dunnock and Lee J. Cobb. The play galvanized the 1949 New York theater world, not only for its drama but also for its setting, created by stage designer Jo Mielziner. A single unit, it gave the illusion of multiple settings with an ingenious use of lighting and props.* (Right) *The open-air Delacorte Theater in New York City's Central Park was the site for this 1984* Henry V, *starring Kevin Kline. Director Wilford Leach mounted a traditional production with opulent costumes and a single set: a small but elegant castle that split in two at act 4, scene 4, to reveal the smoke and carnage of the battlefield at Agincourt.*

theaters have used arena staging or THEATER IN THE ROUND—an innovation whose antecedents can be traced to the theaters of prehistory. The eclecticism that pervades the 20th-century theater is perhaps best summarized in the international career of the Austrian director Max REINHARDT, who worked in an amazing variety of locales in which each production received its own unique style and scenic treatment.

As with design, architecture, and theatrical direction, there is no dominant style of acting in the 20th century. METHOD ACTING, derived from Stanislavsky's teachings, has been found useful by many directors and actors in naturalistic productions (see ACTORS STUDIO), but it is also recognized that deliberately artificial styles are more appropriate to the works of dramatists outside the realistic tradition. Bertolt BRECHT—whose theories of production have perhaps been more influential than those of anyone else in the second half of the century—always insisted that actors in his plays remain aware of the fact that they were acting and that they not surrender their personalities to the characters they were impersonating. Lest the actors themselves prove incapable of such detachment, Brecht employed a number of devices to "alienate" his audiences from any illusions of reality that might endanger their objectivity.

Both realistic and nonrealistic traditions of production flourish in the contemporary theater. Although audiences may not approve, neither are they apt to be surprised when such revolutionary groups as the LIVING THEATRE not only seek to arouse their audiences to some social action but deliberately go out of their way to embarrass and insult them, or when a director such as Peter BROOK, in a variation of the Chinese theater, introduces acrobatics and juggling into a production of Shakespeare's *A Midsummer Night's Dream.* The theater, as these experiments serve to remind us, continues to be an evolving institution—as viable, as exciting, and sometimes as controversial as it was in the days of Aeschylus, Shakespeare, and Ibsen.

theater in the round A performing space surrounded on all sides by the audience, usually in raked or tiered seats, theater in the round creates an intimacy not possible with proscenium stages and makes the audience more aware of itself. Glenn Hughes's Penthouse Theatre at the University of Washington (1940) was the first modern theater totally devoted to this form; Margo JONES's Theatre '50 in Dallas (1950) became the first professional arena stage.

theater of cruelty see ARTAUD, ANTONIN

theater of fact The type of political drama known as theater of fact, or documentary theater, was made famous by Erwin PISCATOR in his productions of Rolf HOCHHUTH's *The Deputy* (1963; Eng. trans., 1964), Heinar Kipphardt's *In the Matter of J. R. Oppenheimer* (1964; Eng. trans., 1967), and Peter WEISS's *The Investigation* (1965; Eng. trans., 1966). The staging of a documentary play characteristically employs factual material—such as reports, conference minutes, journals, newspaper articles, photos, films, or tape recordings—to relate the course of an important historical incident from a new critical perspective. The audience is led to question the authenticity of the accepted or official version of an event by the very framework of the play, which assumes the general form of a trial. This dramatic structure allows for a new hearing of the events that often leads to a new verdict. The facts themselves are tendentious, selected with a view toward agitating the audience and thereby raising its political consciousness.

(Left to right) *Peter Bull, Paul Daneman, Peter Woodthorpe, and Timothy Bateson are seen in a 1955 production of Samuel Beckett's absurdist play* Waiting for Godot *(1952).* Waiting for Godot *defines humanity as hapless characters endlessly and futilely awaiting the arrival of an unknown but presumably beneficent authority.*

theater of the absurd The theater of the absurd refers to tendencies in dramatic literature that emerged in Paris during the late 1940s and early '50s in the plays of Fernando ARRABAL, Samuel BECKETT, Jean GENET, Eugène IONESCO, Jean TARDIEU, and Arthur Adamov. Its roots can be found in the allegorical morality plays of the Middle Ages and the *autos sacramentales* (allegorical religious dramas) of baroque Spain; the nonsense literature of writers such as Lewis Carroll; the dream plays of Strindberg and the dream novels of James Joyce and Franz Kafka; the grotesque drama of Alfred JARRY; and the frantic farces of Georges FEYDEAU. Its direct forerunners were the DADA movement and the SURREALISM of the 1920s and '30s. One of its most potent theoretical sources was *The Theater and its Double* (1938; Eng. trans., 1958) by Antonin ARTAUD.

The term *theater of the absurd* derives from the philosophical use of the word *absurd* by such existentialist thinkers as Albert CAMUS and Jean Paul SARTRE. Camus, particularly, argued that humanity had to resign itself to recognizing that a fully satisfying rational explanation of the universe was beyond its reach; in that sense, the world must ultimately be seen as absurd.

The playwrights loosely grouped under the label of the absurd endeavor to convey their sense of bewilderment, anxiety, and wonder in the face of an inexplicable universe. They rely heavily on poetic metaphor as a means of projecting outward their innermost states of mind. Hence, the images of the theater of the absurd tend to assume the quality of fantasy, dream, and nightmare; they do not so much portray the outward appearance of reality as the playwright's emotional perception of an inner reality. Thus Beckett's *Happy Days* (1961) expresses a generalized human anxiety about the approach of death through the concrete image of a woman sunk waist-deep in the ground in the first act and neck-deep in the second.

Writers outside France who showed the influence of the theater of the absurd include Harold PINTER and Tom STOPPARD in England, Günter GRASS and Peter WEISS in Germany, Edward ALBEE, Israel Horovitz, and Sam SHEPARD in the United States, and Václav HAVEL in Czechoslovakia.

Thebes (Egypt) [theebz] A capital of ancient Egypt, Thebes rose in importance as the home of several royal families from the 11th dynasty (established *c.*2133 BC). Kings of the 12th dynasty lived near Memphis but honored the Theban god Amon, and under the 17th and 18th dynasties Thebes became the capital of the Egyptian empire. Kings of the 19th and 20th dynasties lived in the north but lavished attention on Thebes. As the empire began to decline (*c.*1200 BC), Thebes was controlled by militaristic high priests; in 661 BC the city was sacked by the Assyrians. Thebes continued to be an important center during Ptolemaic times (304–30 BC), but it declined thereafter and now consists of the villages of Luxor and Karnak.

On the east bank of the Nile the principal ancient town site is covered by modern settlements, but two great temple complexes remain. Amon's temple at KARNAK is the larger, covering more than 54 ha (133 acres) and representing almost 2,000 years of building activity (from 2000 BC). The other temple, at LUXOR, was begun in 1417 BC. On the west bank are tombs of 11th- and 17th- to 20th-dynasty royalty. The New Kingdom burial grounds are in the remote valley where TUTANKHAMEN's tomb was found. Several large royal funerary temples survive at the edge of the river, and the desert foothills are filled with tombs of nobles who lived during the New Kingdom and later. Many of the temples are decorated with paintings that are masterpieces of Egyptian art.

Ruins of the temple of Amon-Re, a major Egyptian deity, are on the east bank of the Nile River at the ancient Egyptian capital of Thebes. The complex of palaces, temples, and funerary structures at Thebes was built over more than two millennia.

Thebes (Greece) Thebes, modern Thívai, was the principal city of BOEOTIA, a region of ancient Greece to the northwest of Athens. It existed in Mycenaean times and retained its importance after the Dorian invasion, although it was unable to unite Boeotia as, for example, Athens had united Attica. In 480–479 BC, Thebes sided with Persia during the PERSIAN WARS but escaped destruction when the Persians were defeated (479) at Plataea, a nearby Boeotian city. A dispute about the control of Plataea sparked the enmity between Thebes and Athens, which continued throughout the 5th century. Thebes was a Spartan ally in the PELOPONNESIAN WAR (431–404).

Thebes's great but brief moment of power came in the 4th century BC, primarily because of the military genius of EPAMINONDAS. After a period of unsuccessful conflict with Sparta, then the leading power of Greece, Thebes won a great victory at Leuctra in 371, driving the Spartans out of central Greece and invading the Peloponnesus itself. Theban predominance ended soon after Epaminondas's death in the Battle of Mantinea (362). PHILIP II of Macedonia defeated Thebes and Athens in 338 at Chaeronea; a Theban revolt led ALEXANDER THE GREAT to destroy Thebes in 336 BC. The rebuilt city continued undistinguished but tranquil through Roman times.

theft see LARCENY

theism [thee'-izm] Theism is a philosophically or theologically reasoned understanding of reality that affirms that the source and continuing ground of all things are in God; that the meaning and fulfillment of all things lie in their relation to God; and that God intends to realize that meaning and fulfillment. Theism represents a reasoned articulation of the understanding of God characteristic of the Jewish, Christian, and, to some extent, Islamic faiths.

Themistocles [thuh-mis'-tuh-kleez] Themistocles, *c.*524–*c.*460 BC, one of the greatest statesmen of Athens, was the creator of the Athenian navy and, through it, of the Athenian empire. In 483 he persuaded Athens to build a fleet with the revenues made available from newly discovered silver mines. This fleet and Themistocles' brilliant strategies crushed the Persian king XERXES I's hopes of conquest at the Battle of SALAMIS (480). Soon thereafter Athens became the dominant power of the DELIAN LEAGUE.

About 472, Themistocles was ostracized or banished on suspicion of plotting with the Persians. Retiring to Argos, he instigated trouble for Sparta, which he regarded as the natural opponent of Athens. These dealings and his alleged association with the discredited Spartan regent PAUSANIAS led to a charge of treason. Condemned to death, Themistocles made a sensational escape to the Persian court, where he was granted fiefs by Artaxerxes I in exchange for his loyalty.

Theocritus [thee-ahk'-ri-tuhs] The Greek poet Theocritus, *c.*310–*c.*250 BC, wrote 30 short poems, the *Idylls,* on pastoral and mythical subjects, love, and scenes of contemporary society. His bucolic poems strongly influenced Vergil's *Eclogues* and thereafter the development of PASTORAL LITERATURE.

theodolite see SURVEYING

Theodora, Byzantine Empress Theodora, b. AD *c.*500, d. June 548, was the celebrated wife of the Byzantine emperor JUSTINIAN I. In his *Secret History,* Procopius of Caesarea alleges that before her marriage (525) she had been an actress and prostitute. Her charms and personality undeniably exerted great influence over Justinian. During the Nika Riot (532) her vigorous encouragement prevented him from fleeing the capital and thereby probably saved his crown. Her influence on public policy could be decisive, but she had only a partial success in winning her husband's tolerance of MONOPHYSITISM.

Theodore of Mopsuestia [mahp-soo-es'-chuh] A biblical commentator and bishop of Mopsuestia in Cilicia, Theodore, *c.*350–428, was a representative of the Christology of the Antiochene school. In his interpretation of Scripture, he employed a critical and scientific approach, taking a historical rather than an allegorical approach to Genesis and the Psalms. Theodore's Christology, although it contributed to NESTORIANISM, anticipated the formula adopted at the Council of CHALCEDON (451) on the dual but united natures of Christ. His views were nevertheless condemned at the Councils of Ephesus and Constantinople (553).

Theodoret [thee-ahd'-uh-ret] A theologian of the Antiochene school, Theodoret, b. Antioch, *c.*393, d. *c.*458, was a monk of Apamea and bishop of Cyrus, Syria (423). A friend of Nestorius (see NESTORIANISM), he became embroiled in the controversy with Saint CYRIL OF ALEXANDRIA, whose views, he held, implied a confusion of the divine and human natures of Christ. Cyril's successor, the powerful Dioscorus, accused (448) Theodoret of dividing Christ into two natures, and although Theodoret insisted on the unity, he was anathematized. The Robber Synod of Ephesus (449), defending Cyril's theology, deposed Theodoret and forced him into exile for a year.

Theodoric the Great, King of the Ostrogoths [thee-ahd'-ur-ik] Theodoric, b. *c.*455, d. Aug. 30, 526, was king (471–526) of the Ostrogoths (see GOTHS) and ruler (493–526) of Italy. He spent much of his youth as a hostage in Constantinople. Succeeding his father, Theodemir, he established his followers in what is today Bulgaria. In 488 the emperor Zeno sent Theodoric to drive the Germanic chieftain Odoacer out of Italy. Theodoric slew Odoacer and took control of Italy. He employed able Roman administrators, patronized the arts, and sought the support of influential Romans, including the philosopher Boethius. Theodoric's plans to establish harmony between Goths and Romans failed, however, in part because his people adhered to Arianism, and the Romans, to orthodox Catholic Christianity. Theodoric was also unable to achieve his goal of uniting the Germanic dynasties of the West through a matrix of marriage alliances. A few years after his death Justinian I destroyed the Ostrogothic state.

Theodosius I, Roman Emperor (Theodosius the Great) [thee-oh-dohz'-ee-uhs] Theodosius I, b. Jan. 11, 347, d. Jan. 17, 395, was the last ruler of the whole Roman Empire. He was given a military education by his father, a general, and was selected by Gratian, ruler of the western half of the empire, to succeed Valens in the East and to control the incursions of the GOTHS. In 382, to end the Visigoths' ravages, he concluded a treaty that granted them territory north of the Balkan Mountains. Theodosius found his realm divided between Catholic and Arian Christians (see ARIANISM). In 381 he therefore convened the First Ecumenical Council of Constantinople (see CONSTANTINOPLE, COUNCILS OF), which produced new theological formulas that convinced most Arians to convert to Catholicism.

Twice Theodosius intervened in the West. After Gratian's death, he recovered the western part of the empire (388) from the usurper Maximus and remained in Italy until 391, supporting Valentinian II. During this stay, Saint AMBROSE, bishop of Milan, excommunicated Theodosius for his massacre (390) of the people of Thessalonica; only public penance won the emperor forgiveness. Valentinian died in 392, and Theodosius soon began to assert his authority over the West. In 394, to suppress the pagan pretender Eugenius, he again invaded Italy and briefly reunified the empire. He left the East to his elder son, Arcadius, and the West to his son Honorius.

Theodosius I (the Great), the last ruler of the whole Roman Empire, combated Arianism and paganism within the empire. He convened (381) the First Council of Constantinople, which established the orthodox Christian teaching on the Trinity.

theological seminaries A theological seminary is a professional school in which Protestant ministers, Roman Catholic and Orthodox priests, and rabbis receive their training. Seminaries accept people who hold at least a bachelor's degree. Seminary curricula generally consist of history, theology, scripture, ethics, biblical languages, and subjects related to pastoral duties.

Protestant Seminaries

Protestant seminaries, as separate professional schools, are largely a product of the 19th century, their greatest period of growth corresponding to the rise of denominationalism, from about 1820 to 1880. Before that time education for the ministry consisted of the usual collegiate curriculum followed by a brief apprenticeship with a clergyman.

Of the more than 100 accredited, predominantly Protestant seminaries in the United States and Canada, some 18 percent are interdenominational schools. A substantial number are integral parts of universities. Since 1965 there has been a rapid growth in the cluster, or consortium-based, seminary, in which the member seminaries, sometimes both Protestant and Roman Catholic, share curricula, libraries, and other resources. Students enrolled in Protestant seminaries total nearly 40,000, of which about a fifth are women. The number of specialized courses for women and for blacks is increasing.

Although most seminary students plan to be ordained, many enter a seminary in order to investigate such a life's work or to earn a degree in theological studies. After 3 to 4 years of study the degrees of B.D., Th.M., and D.Min. are awarded.

Roman Catholic Seminaries

Although the first Roman Catholic seminaries in the United States were founded at the beginning of the 19th century, the period of most rapid expansion occurred from 1880 to 1910, with many dioceses establishing parish-oriented seminaries and with religious orders founding their own seminaries. Admission requires a degree from an accredited college, university, or collegiate seminary, plus sponsorship by the appropriate Ordinary. Although women are not eligible for ordination, they may nevertheless enroll in seminary degree programs. The 4-year course of study leads to the M.Div. or M.A. degree.

Jewish Seminaries

Since the late 19th century each of the major traditions of Judaism has maintained a seminary. The seminary for Orthodox Judaism is part of Yeshiva University in New York City and others a 3-year course. The seminary for Conservative Judaism is the Jewish Theological Seminary, also in New York City, offering a 6-year course of study. The seminary for Reformed Judaism is The Hebrew Union College–Jewish Institute of Religion in Cincinnati, Ohio. At ordination all the seminaries confer the title of rabbi on the candidates, with an M.A. or a D.H.L. being conferred after 2 or 3 years of further study.

The largest professional association of seminaries is the Association of Theological Schools of the United States and Canada.

theology The term *theology* is a compound of the Greek words *theos* ("god") and *logos* ("word," "discourse," "thought," "reason"). Theology may therefore be defined as reasoned discourse about God. In a strict sense theology considers only the existence and nature of divine being. In its wider and more usual sense, however, it may encompass the full range of the divine's relationships to the world and to humanity as well as the full variety of human responses to the divine. Although used more commonly of Western religions, the term may be applied to the systematic study and presentation of any religion.

The first to use the term was apparently the Greek philosopher Plato, for whom theology meant a rational conception of the divine as opposed to poetic myths about the gods. The subsequent Greek tradition of rational theology survived well into Christian times, and aspects of it have been influential in shaping various Jewish, Christian, and Islamic theologies.

In early Christianity, theology had a number of meanings. It referred, for instance, to the whole mystery of God, to particular teachings about God (for example, the doctrine of the Trinity), or to a stage in the mystical knowledge of God. In general, however, theology implied an understanding of God over and above simple belief in God. Only in the medieval period did theology become an academic field, or "science," in somewhat the modern sense. With the rise of medieval universities, theological faculties began to emerge, and theology itself came to be defined as a science like other sciences in the medieval curriculum. It proceeded from its own first principles, followed accepted canons of rational inquiry, and produced an organized body of knowledge in its own right. Since the Middle Ages theology has included both academic and nonacademic forms of religious inquiry, often in tension with each other.

In the course of its history theology has been subdivided according to various patterns. One typical pattern distinguishes between historical, systematic, and philosophical theology. The first studies the content of a religious tradition; the second attempts comprehensive explanations and expositions of its doctrines; and the third investigates the philosophical presuppositions and implications of religious belief. Also important are moral theology, or ethics, which explores the moral dimensions of the religious life, and practical theology, which interprets the forms of worship, styles of organization, and modes of interpersonal relationship within religious communities.

Although different questions have preoccupied theologians at different times, certain topics have established themselves as basic to theological study. These include the basis for humans' knowledge of God, the being and attributes of God, the relation of God to the world and of the world to God, the modes of divine governance of human affairs, the source and character of human alienation from the divine, the manner of humanity's restoration to God, and the ultimate destiny of humankind.

Theophrastus [thee-oh-fras'-tuhs] A Greek philosopher and scientist and Aristotle's most famous pupil, Theophrastus, *c.*371–*c.*286 BC, headed the PERIPATETICS following Aristotle. Although he criticized some basic Aristotelian positions, Theophrastus's works were primarily developments of those of Aristotle, with the emphasis on the empirical and scientific. Theophrastus's own scientific works, particularly those in botany, were highly influential. Theophrastus is also known for his *Doctrines of the Natural Philosophers*; for *Characters*, a satirical study of ethical types; and for his contributions to logic.

theosophy The term *theosophy* is derived from the Greek *theos* ("god") and *sophia* ("wisdom") and means wisdom of or about God. In a general sense, theosophy refers to a broad spectrum of occult or mystical philosophies, often pantheistic in nature. The Western theosophical tradition is characterized by an emphasis on the hidden tradition passed down in a succession from the ancients. This tradition is thought to provide a universal key to nature and to humanity's role therein.

More specifically, the term refers to the Theosophical Society, its offshoots, and the doctrines held by its members. The most important early figure in the movement was Helena Petrovna BLAVATSKY, who, along with H. S. Olcott (1832–1907) and W. Q. Judge (1851-96), founded the society in 1875. Blavatsky elaborated an amalgamation of previous theories that were claimed to be derived from the mahatmas of ancient India.

According to Madame Blavatsky, the doctrines of theosophy rest on three fundamental propositions. The first postulates an omnipresent, boundless, and immutable principle that transcends human understanding. It is the one unchanging reality, or infinite potentiality, inherent in all life and covers all that humans have tried to say about God. The second deals with the universality of the law of periodicity recorded by science as found in all nature. As morning, noon, and night are succeeded by morning again, so birth, youth, adulthood, and death are succeeded by rebirth. Reincarnation is the process of human development, in which all growth is governed by the law of justice or KARMA. The third proposition declares the fundamental identity of all souls with the universal Over-Soul,

Annie Besant, president (1907–33) of the Theosophical Society in Asia and Europe, was photographed (1923) in Bombay with Indian political leaders.

suggesting that brotherhood is a fact in nature, and the obligatory pilgrimage for every soul through numerous cycles of incarnation (see TRANSMIGRATION OF SOULS). Theosophy admits of no privileges or special gifts in humans except those won by their own effort and merit. Perfected individuals and great teachers, such as Buddha, Jesus, and the mahatmas, are universal beings, the flower of evolution.

After the death (1891) of Madame Blavatsky a battle for leadership of the society ensued, from which Annie BESANT emerged as leader in Europe and Asia, whereas W. Q. Judge led a secessionist movement in the United States. Under Besant, the society flourished. In 1911 she put forward Jiddu KRISHNAMURTI as a World Teacher, around whom she founded the Order of the Star of India. This action provoked Rudolf STEINER, who, with a large number of followers, left to found the Anthroposophical Society.

Thera [thee'-ruh] Thera is the ancient name of the Cycladic island of Thíra (also called Santorini) in the southern Aegean; it has an active volcano. In the middle of the 2d millennium BC an eruption of the explosive type, like that which overwhelmed Pompeii, buried Thera's flourishing Bronze Age settlements beneath meters of pumice. Subsequent collapse of the magma chamber formed the impressive sea-filled caldera and left three small islands in place of the previous large one. The main island (present-day Thíra) was resettled before the end of the Bronze Age and was later (9th century BC) occupied by Dorian Greeks, who built their city on a limestone height to the east of the modern village of Akrotiri.

Comparing the artifacts and ruins of Thera with those found at other Bronze Age sites, archaeologists have traditionally dated the destruction of Thera at about 1500 BC. Evidence from radiocarbon dating of plant remains on Thera, anomalies in the world dendrochronological (tree ring) record, and volcanic deposits buried in Greenland's ice sheets, however, suggest that 1628 BC is a more accurate date. Due to the new evidence, archaeologists may have to redate some events relevant to Minoan culture. Considerable controversy also surrounds the speculations that the Greek legend of ATLANTIS may be linked to the cataclysmic destruction of Thera.

Theramenes [thuh-ram'-uh-neez] Theramenes, d. 404 BC, an Athenian politician active in the final stage of the PELOPONNESIAN WAR, was a founding member of the Four Hundred, a conservative or oligarchic group that seized power in 411 BC. Breaking with it four months later, he helped to establish a more moderate group, the Five Thousand, but then endorsed the restoration of full democracy. He was active in the naval war against Sparta. After the Battle of Aegospotami, Theramenes negotiated peace in 404, became one of the Thirty Tyrants—a reactionary group then installed as the government—and shortly thereafter was condemned to death in a dispute with Critias, the most radical of the Thirty.

therapsid see MAMMAL

Theravada Buddhism see BUDDHISM

theremin [thair'-uh-min] The theremin, one of the first successful electronic musical instruments, was invented about 1924 by the Russian Leon Theremin. Pitches are controlled by the proximity of the player's right hand to the instrument; the left hand controls the volume. It is capable of playing only melodies. The theremin fell into disuse about the middle of the century, when the attention of composers was captured by the invention of more sophisticated electronic instruments (see ELECTRONIC MUSIC).

Thérèse, Saint [tay-rez'] Saint Thérèse of Lisieux, b. Thérèse Martin in Alençon, France, Jan. 2, 1873, d. Sept. 30, 1897, is one of the most popular saints of the Roman Catholic church. Her brief life was marked by its simplicity and goodness. Her spiritual autobiography, *The Story of a Soul* (1898; Eng. trans., 1958), aroused great interest. Known as the "Little Flower of Jesus," she was canonized on May 17, 1925. Saint Thérèse is the patron of foreign missions—with Saint Francis Xavier—and of aviators. Feast day: Oct. 3.

thermionic emission Thermionic emission is the phenomenon by which electrons are emitted into a vacuum as a result of the thermal excitation of a metal or oxide-coated conductor. The cathode of an ELECTRON TUBE, for instance, is a thermionic emitter. Although thermionic emission can be observed in all metals, tungsten and tantalum are particularly efficient thermionic emitters. Rare-earth oxides of barium and strontium are also used.

Thermionic emission is also known as the Edison effect, because Thomas A. EDISON discovered (1883) the phenomenon while developing filaments for the electric light bulb.

thermistor [thur'-mis-tur] A thermistor is a small electronic component, made from a SEMICONDUCTOR (often manganese and nickel oxides), that changes its electrical resistance in response to temperature changes. Used to measure temperature electronically, it also serves to compensate for excessive power consumption by an electronic circuit by sensing the accompanying temperature increase and applying negative feedback; this feedback returns the circuit to a safe operating level (see RESISTOR).

thermochemistry Thermochemistry is a branch of physical science that studies the energy changes that take place when a chemical reaction or phase change occurs. The energy change is usually caused by the breaking or forming of chemical bonds in a reaction, and the energy change is called the heat of the reaction. When a chemical bond is broken, energy is absorbed, and when a chemical bond forms, energy is given off.

When the relationship between work and heat was first investigated, it was shown that they are both forms of energy. The most important studies were conducted from 1840 to 1850 by James Prescott JOULE, who discovered that mechanical work could be converted to heat. Heat is commonly measured in calories (a calorie, abbreviated cal, is defined as the amount of heat required to raise the temperature of one gram of water one Celsius degree). The unit of work, heat, and energy in general in the international system of units used in science has been named in Joule's honor. The two units are related in this way: 1 calorie = 4.184 joules. Joule also discovered that when energy apparently disappears it is actually converted to another form of energy. His work led to the law of conservation of energy, which states that energy can be neither created nor destroyed but may be transformed from one form to another. This law is one way of stating the first law of thermodynamics and is the basis for the fundamental concepts of thermochemistry.

Heat of Reaction. The quantity of heat liberated or absorbed by substances undergoing reaction is called the heat of reaction. Experimental measurements of this heat can be done directly in a calorimeter. The change in heat is symbolized by ΔH and is given a negative sign if the reaction liberates energy (exothermic) or a positive sign if energy is absorbed (endothermic).

Heat of Formation. The heat of reaction for formation of one mole of a compound from its elements is the compound's molar heat of formation, ΔH_f. This quantity is a useful indicator of the stability of the compound. Most compounds have negative heats of formation, because energy is released in their formation.

Compounds with a high negative heat of formation are very stable. Those with a small heat of formation, positive or negative, are generally unstable. They often are easily decomposed or will react readily. If a compound has a large positive heat of formation, it may react violently or decompose explosively because of the large amounts of energy stored within it.

Heat of Combustion. The heat of combustion, ΔH_c, of a substance is the heat of reaction for the complete combustion of one mole of a substance. The heat of combustion of hydrogen, for example, is the same as the heat of formation of water, $H_2 + \frac{1}{2} O_2 \rightarrow H_2O$, $\Delta H_f = \Delta H_c = -68.32$ kcal. Combustion data for various fuels are important to engineers developing heat/energy systems.

Determination of Heat of Reaction. In order to calculate the heat of a reaction, also known as the change in enthalpy, the heat content of the reactants is determined and subtracted from the heat content of the products.

Other Thermochemical Values. Entropy is a quantity that measures the disorder in a chemical substance (see THERMODYNAMICS). The change in entropy, ΔS, for a reaction is equal to the entropy of the products minus the entropy of the reactants.

Another property that can be determined for a chemical reaction is the free-energy change. This quantity was first defined in 1875 by the American physicist Josiah Willard Gibbs as the amount of energy in a system that can be converted to useful work (at constant temperature and pressure). This amount may be calculated from the differences in the final and initial free energy of the substances or from $\Delta G = \Delta H - T\Delta S$, where T is the absolute temperature in kelvin units (25° C = 298 K). In general, reactions that have a large, negative change in free energy are spontaneous; that is, they tend to occur without the addition of external energy (see CHEMICAL ENERGY).

thermocline A thermocline is a permanent or temporary boundary layer formed in oceans and lakes between warm and cold water masses. Little or no water moves through the thermocline, because water density changes with water temperature. The depth of the thermocline varies with the season and with the latitude, and its permanence in any given body of water depends on these and other factors, such as mixing processes within the water and meteorological processes affecting the water surface. Generally, during the fall (during monsoon season in tropical climates), deeper lakes undergo a mixing process that temporarily destroys the thermocline. The deepest thermocline in the world ocean is more or less symmetrical about the equator, with its upper surface from 100 to 700 m (300 to 2,300 ft) below the ocean surface, and ending about 55° north or south latitude. This thermocline is permanent in the sense that its changes do not depend on seasonal or shorter-period changes.

thermocouple A thermocouple is a small electrical device used for measuring temperature. It consists of two wires of dissimilar metals joined together at their ends, forming two junctions. If the junctions are at different temperatures, a voltage will be produced that is approximately proportional to the temperature difference, a phenomenon discovered by the German physicist Thomas Seebeck (1770–1831). The voltage produced can be measured and used to determine the temperature at one junction if the other junction is kept at a known temperature (usually 0° C [32° F]).

Thermocouples can be made from various combinations of materials, depending on the temperature range that is to be measured. Platinum and a platinum-rhodium alloy, chromel and alumel, and iron and constantan are some of the combinations commonly used. Some thermocouples can measure temperatures down to –200° C (–330° F), whereas others can operate at values as high as 1,800° C (3,200° F). Small temperature differences can be measured more accurately by using a thermopile, a device consisting of several thermocouples arranged in series. In a thermopile, the small voltage outputs of each element are added, thus permitting a greater response to a given temperature change than is available with a thermocouple.

See also: THERMOELECTRICITY.

thermodynamics Thermodynamics is the branch of the physical sciences that studies the transfer of heat and the interconversion of heat and work in various physical and chemical processes. The word *thermodynamics* is derived from the Greek words *thermos* ("heat") and *dynamis* ("power"). The study of thermodynamics is central to both chemistry and physics and is becoming increasingly important in understanding biological and geological processes.

There are several subdisciplines within this blend of chemistry and physics. These include: classical thermodynamics, which considers the transfer of energy and work in macroscopic systems—that is, without any consideration of the nature of the forces and interactions between individual (microscopic) particles; statistical thermodynamics, which considers microscopic behavior, describing energy relationships on the statistical behavior of large groups of individual atoms or molecules and relying heavily on the mathematical implications of quantum theory; and chemical thermodynamics, which focuses on energy transfer during chemical reactions and the work done by chemical systems (see PHYSICAL CHEMISTRY).

Thermodynamics is limited in its scope. It emphasizes the initial and the final state of a system (the system being all of the components that interact) and the path, or manner, by which the change takes place, but it provides no information concerning either the speed of the change or what occurs at the atomic and molecular levels during the course of the change.

Development of Thermodynamics

The early studies of thermodynamics were motivated by the desire to derive useful work from heat energy. The first reaction turbine was described by Hero (or Heron) of Alexandria (AD *c.*120); it consisted of a pivoted copper sphere fitted with two bent nozzles and partially filled with water. When the sphere was heated over a fire, steam would escape from the nozzles and the sphere would rotate. The device was not designed to do useful work but was instead a curiosity, and the nature of HEAT AND HEAT TRANSFER at that time remained mere speculation.

The changes that occur when substances burn were initially accounted for, in the late 17th century, by proposing the existence of an invisible material substance called PHLOGISTON, which was supposedly lost when combustion took place.

In 1789, Antoine LAVOISIER prepared oxygen from mercuric oxide; in doing so he demonstrated the law of conservation of mass and thus overthrew the phlogiston theory. Lavoisier proposed that heat, which he called *caloric,* was an element, probably a weightless fluid surrounding the atoms of substances, and that this fluid could be removed during the course of a reaction. The observation that heat flowed from warmer to colder bodies when such bodies were placed in thermal contact was explained by proposing that particles of caloric repelled one another.

Somewhat simultaneous to these chemical advances, the actual conversion of heat to useful work was progressing as well. At the end of the 17th century Thomas Savery invented a machine to pump water from a well, using steam and a system of tanks and hand-operated valves. Savery's pump is generally hailed as the first practical application of steam power. Thomas Newcomen developed Savery's invention into the first piston engine in 1712. The design of the steam-powered piston engine was further refined by James WATT during the last quarter of the 18th century.

Mechanical Equivalent of Heat. The downfall of the caloric theory was initiated by Sir Benjamin Thompson, Count Rumford. After spending his early years in America and England, Thompson became a minister of war and minister of police in Bavaria. In 1798, while overseeing the boring of cannon at the Munich Arsenal, Thompson noted that an apparently inexhaustible amount of heat was produced during the procedure. By having the cannon bored underwater, he found that a given quantity of water always required the same amount of time to come to a boil. If the caloric theory were correct, there would come a time when all of the caloric had been removed from the atoms of the cannon and no more heat would appear. Instead, Thompson interpreted his results as a demonstration that work was being converted into heat, just as the steam engines of his time converted heat into work. In 1799, Sir Humphry DAVY demonstrated that pieces of ice melt more rapidly when rubbed together, even in a vacuum. This provided additional support to the idea that work could be converted into heat.

A precise determination of the mechanical equivalent of heat was reported in 1849 by James JOULE. With the use of very precise homemade thermometers, Joule found that by stirring water (mechanical work input), its temperature was increased (heat output). His conversion factor of 0.241 calories of heat energy equaling 1 joule of work was based on the observation that to generate 1 calorie of heat, a 1-kg weight must fall through a distance of 42.4 cm (the work performed by the falling weight was used to mechanically stir the water).

Joule also electrically heated gases and measured the resulting pressure changes; he found similar results there on the interconversion of work and heat.

The First Law of Thermodynamics. The findings of Joule and others led Rudolf CLAUSIUS, a German physicist, to state in 1850 that "In any process, energy can be changed from one form to another (including heat and work), but it is never created or destroyed." This is the first law of thermodynamics. An adequate mathematical statement of this first law is $\Delta E = q - w$, where ΔE is the change (Δ) in internal energy (E) of the system, q is the heat added to the system (a negative value if heat is taken away), and w is work done by the system. In thermodynamic terms, a system is defined as a part of the total universe that is isolated from the rest of the universe by definite boundaries, such as the coffee in a covered Styrofoam cup; a closed room; a cylinder in an engine; or the human body. The internal energy, E, of such a system is a state function; this means that E is dependent only on the state of the system at a given time, and not on how the state was achieved.

If the system considered is a chemical system of fixed volume—for example, a substance in a sealed bulb—the system cannot do work (w) in the traditional sense, as could a piston expanding against an external pressure. If no other type of work (such as electrical) is done on or by the system, then $\Delta E = q_v$, which means that an increase in internal energy is equal to the amount of heat absorbed at constant volume (the subscript v indicates that the volume of the system remains constant throughout the process). If the heat is absorbed at constant pressure instead of constant volume (which can occur to any unenclosed system), the increase in the energy of the system is represented by the state function, H, which is closely related to the internal energy. Changes in H (heat content) are called changes in enthalpy.

In 1840, before Joule had made his determinations of the mechanical equivalent of heat, Germain Henri Hess reported the results of experiments that indicated that the heat evolved or absorbed in a given chemical reaction (ΔH) is independent of the particular manner (or path) in which the reaction takes place. This generalization is now known as HESS'S LAW and is one of the basic postulates of THERMOCHEMISTRY.

The Second Law of Thermodynamics. The steam engine developed by James Watt in 1769 was a type of heat engine, a device that withdraws heat from a heat source, converts some of this heat into useful work, and transfers the remainder of the heat to a cooler reservoir. A major advance in the understanding of the heat engine was provided in 1824 by N. L. Sadi Carnot, a French engineer, in his discussion of the cyclic nature of the heat engine. This theoretical approach is known as the CARNOT CYCLE.

A result of the analysis of the heat engine in terms of the Carnot cycle is the second law of thermodynamics, which may be stated in a variety of ways. According to Rudolf Clausius, "It is impossible for a self-acting machine, unaided by external agency, to convey heat from a body at one temperature to another body at a higher temperature." William Thomson (Lord KELVIN), a British thermodynamicist, proposed that "it is impossible by a cyclic process to take heat from a reservoir and convert it into work without, in the same operation, transferring heat from a hot to a cold reservoir."

Entropy. The second law of thermodynamics leads to a new state function S, the ENTROPY of a system. The increase in the entropy of a system when heat is added to it must be at least q/T, where q is the added heat and T is the absolute temperature. If the heat is added in an idealized (reversible) process, $\Delta S = q/T$, but for real (irreversible) processes, the entropy change is always greater than this value.

Ludwig BOLTZMANN, an Austrian physicist, demonstrated the significance of entropy on the molecular level in 1877, relating entropy to disorder. J. Willard GIBBS, an American mathematical physicist, referred to entropy as a measure of the "mixed-upedness" of the system.

The second law of thermodynamics may also be stated in terms of entropy: in a spontaneous irreversible process, the total entropy of the system and its surroundings always increases; for any process, the total entropy of a system and its surroundings never decreases.

The Third Law of Thermodynamics. Entropy as a measure of disorder is a function of temperature, increasing temperature resulting in an increase in entropy (positive ΔS). The third law of thermodynamics considers perfect order, and it states that the entropy of a perfect crystal is zero only at ABSOLUTE ZERO. This reference point allows absolute entropy values to be expressed for compounds at temperatures above absolute zero.

Scope of Thermodynamics

While thermodynamics does not deal with the speed of a chemical reaction, the driving force (or spontaneity) of a chemical reaction is a thermodynamic consideration. A reaction is said to be spontaneous if the reactants and the products of a chemical reaction are mixed together under carefully specified conditions and the quantity of the products increases while the quantity of reactants decreases. The spontaneity (or, less precisely, the direction) of a chemical reaction may be predicted by an evaluation of thermodynamic functions.

Thermodynamics also studies changes in physical state, such as solid ice becoming liquid water. At temperatures above 0° C and at atmospheric pressure, ice spontaneously melts, resulting in a liquid that is much more disordered than solid water. At 0° C and atmospheric pressure, solid ice and liquid water exist in PHASE EQUILIBRIUM, a condition in which all forces in the system are balanced. A phase may be considered a homogeneous region of matter separated from other homogeneous regions by phase boundaries. For a pure substance, three phases are generally considered: solid, liquid, and vapor. Other types of phases exist, such as the two solid crystalline forms of carbon (graphite and diamond), and the ionized gaseous phase of matter known as plasma (see PLASMA PHYSICS).

The nonideal behavior of gases has an important thermodynamic consequence. If an IDEAL GAS is allowed to pass through an orifice from a region of higher pressure to one of lower pressure, no heat is evolved or absorbed, no change in internal energy has taken place, and therefore there is no change in temperature. Real gases, however, behave differently. All real gases, except for hydrogen and helium, cool when expanded in this fashion. If no heat is transferred (an ADIABATIC PROCESS, or one in which $q = 0$), the internal energy of the system decreases because of the work done by the system in decreasing the attractive forces between the gas molecules. This phenomenon is called the Joule-Thomson effect and has significance in such areas as refrigeration, the liquefaction of gases, and artificial snow production.

Statistical Thermodynamics

The major concern of thermodynamics is the state functions and the properties of the macroscopic system. Statistical thermodynamics deals with the distribution of the various atoms and molecules that make up the system and with the energy levels of these particles. The second law of thermodynamics on the atomic and molecular level is a statistical law; it expresses a tendency toward randomness and disorder in a system having a large number of particles. Statistical thermodynamics uses probability functions and complex mathematical methods to express thermodynamic functions in accord with the KINETIC THEORY OF MATTER.

thermoelectricity Thermoelectricity is electricity generated by the direct action of heat. The subject also includes the study of heat generated by electricity, but not in the usual manner (Joule heating); the effects are the result of interactions between mobile electric charges and thermal conditions. Thermoelectric effects occur in liquids and solids, which may be metals, semimetals, semiconductors, or ionic conductors. None of the major thermoelectric effects have been found in insulators or superconductors. The three major thermoelectric effects are the Seebeck effect, the Peltier effect, and the Thomson effect..

Seebeck Effect. If a homogeneous material having mobile charges has temperature T_1 at one end and T_2 at the other end while it is in an open circuit, then a difference in electric voltage will occur between the two ends. This voltage is directly proportional to the temperature difference $T_1 - T_2$. If the material is homogeneous, the voltage will depend only on T_1 and T_2 and will be independent of the detailed temperature conditions between the two ends (law of Magnus). The existence of a voltage difference caused by a temperature difference was first reported to the Prussian Academy of Sciences by Thomas Seebeck in 1822.

Peltier Effect. Unlike the Seebeck effect, which occurs in a single material in the presence of a temperature difference without an electric current, the Peltier effect only occurs at the junction of two dissimilar materials when electric current flows. Heat, called the Peltier heat, is either emitted or absorbed at the junction, depending on the direction of current flow. This effect was discovered by the French physicist Jean C. A. Peltier in 1834.

Thomson Effect. In 1854, William Thomson (later to become Lord KELVIN for his contributions in laying the first transatlantic cable) used thermodynamic arguments to relate the Peltier and Seebeck effects. In the process he predicted a third effect—namely, that an electric current flowing through a homogeneous material that also has a temperature difference will cause the emission or absorption of heat in the body of the material. The direction of the electric current relative to the sense of the temperature difference (that is, flowing toward higher or lower temperature) determines whether heat is emitted or absorbed. This effect was subsequently discovered and called the Thomson effect.

Uses. Thermoelectricity is practically applied in two general areas—the use of thermal energy to generate electric energy, and the use of electric energy for heating or refrigeration.

Electrical generation is based on the Seebeck effect. Metals show small Seebeck effects, but material properties dictate their use in thermometers. The THERMOCOUPLE, an open circuit using two dissimilar metals, is a widely used thermometer.

Semiconductors show much larger Seebeck effects, and they are commonly used to generate electric power. Because any source of the heat energy is acceptable, a variety of methods are in use: heat from kerosene lamps and firewood (in remote areas of the Soviet Union), heat from nuclear decays (in space and in floating weather stations), and heat from direct sunlight (in space) have all been combined with semiconductors to generate electric power ranging from a few watts up to several hundred watts.

The Peltier effect is used in refrigeration and heating; a modern single-stage Peltier cooler can reduce temperatures to nearly 70 C degrees (125 F degrees) below room temperature. In comparison to more conventional systems, Peltier coolers have the advantages of very local heat transfer (occurring only at the junction) and no moving parts; they also have the disadvantages of lower efficiencies and higher costs.

Numerous special circumstances have justified the use of a Peltier cooler. Important factors are its durability, resulting from the absence of moving parts, and its versatility—by reversing the current direction, it can be changed from a cooling to a heating system. A number of electronic systems require very local cooling or heating to obtain optimum performance; Peltier systems are ideal in these instances and have been used with transistors, lasers, microwave amplifiers, and light detectors. Peltier coolers have also been used to maintain biological samples during periods of storage and transfer. The largest Peltier-effect systems built so far are air conditioners used on U.S. Navy submarines.

thermography (medicine) Thermography, in medicine, is the measurement of thermal radiation, or heat, given off by the human body. The amount emitted depends on several factors, including state of health; in addition, some body areas have a larger blood supply than others and therefore emit more heat. The devices used to measure these temperature differences produce electronic signals on an oscilloscope, which can then be photographed on special film or projected onto a television monitor. The image produced is called a thermogram.

Inflammatory diseases can be diagnosed with thermography, because arthritic conditions, bone tumors and bone infections such as osteomyelitis, and muscle and tendon diseases resulting from inflammation produce heat radiation. Blockages of blood vessels also can be detected, because areas of reduced blood flow produce "cold spots" on a thermogram. Disorders such as atherosclerosis, which causes decreased circulation to the hands and feet, can therefore be detected in this way. Nerve injury produces cold spots as well, and thermography has proved useful in diagnosing some spine injuries that produce pain and disability but that appear normal according to other tests. Thermography is no longer considered useful, however, for detecting BREAST cancer.

thermography (printing) Thermography (meaning "heated printing"), a means of raised-letter printing that simulates engraved printing at considerably less cost, is used to create special effects for printing letterheads, invitations, greeting cards, and other such purposes. In thermography, special oily, slow-drying inks are used for printing conventionally by letterpress or lithography; the wet inks are then dusted with a fusible powdered compound, and excess powder is removed from the nonprinting areas by suction. The sheet is then passed under a heater that fuses the ink and powder. Another type of ink contains an agent that expands when exposed to heat. This process is not to be confused with the thermographic copying process.

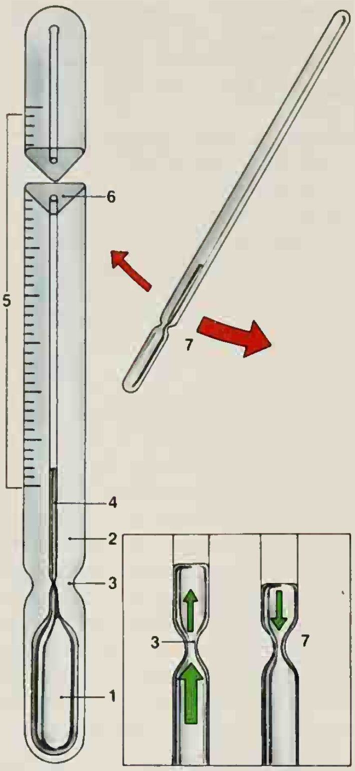
thermometer The thermometer, a device for measuring TEMPERATURE, is used in many forms, basically divided into mechanical and electrical types. The best-known mechanical type is the liquid-in-glass thermometer, and an important electrical type is the resistance thermometer. To cover the full range of temperature measurement, from near absolute zero to thousands of degrees, other instruments are also used, such as the bolometer, pyrometer, THERMOCOUPLE, and thermopile.

The liquid-in-glass thermometer consists of a small bulb reservoir and a calibrated fine-bore capillary tube. The liquid in the bulb rises or falls in the tube as it expands or contracts in response to temperature changes. The height of the column is measured against the markings on the tube, whcih are commonly on the CELSIUS or Fahrenheit scale. Mercury is the preferred liquid in quality thermometers; it freezes at –38.9° C (–38° F) and boils at 357° C (675° F). The accuracy of industrial mercury thermometers is 1% of the column. Other liquids used are dye-colored alcohol, toluene, and pentane, the last with a freezing point of –200° C (–328° F).

A second type of liquid-expansion thermometer consists of a liquid-filled metal bulb and capillary tube attached to either a spiral tube or a bellows. As the temperature of the bulb changes, the pressure or the volume of the liquid changes, moving an indicator across a scale.

A typical gas or vapor thermometer similarly consists of a bulb and a capillary tube connected to a pressure-measuring device. The gas thermometer is simple, rugged, and accurate and has a wide response. Vapor-pressure thermometers respond to the pressure exerted by saturated vapor in equilibrium with a volatile liquid. It is similar to the gas thermometer in construction. The principal advantage of the vapor-pressure type is the large change in pressure obtained for small temperature changes, resulting in high sensitivity.

Electrical resistance thermometers operate on the principle that the resistivity of most metals increases with increased temperature. This principle was discovered in 1821 by Sir Humphry Davy, but this phenomenon was not used until the construction of a platinum resistance thermometer in 1861 by the German engineer Ernst W. von Siemens. In 1886 the British physicist Hugh L. Callendar proposed this thermometer as a new standard of accuracy in temperature measurement. Today the U.S. National Bureau of Standards uses high-precision platinum resistance thermometers, accurate to 0.001° C, to define the key points on the International Practical Temperature Scale, established in 1968. Both copper-wire and nickel-wire resistance thermometers are much lower in cost than platinum and have a precision of 0.05° C. In the range of 10° to 2° above absolute zero, impurity-doped germanium resistance thermometers are used, calibrated against the temperature of liquid helium.



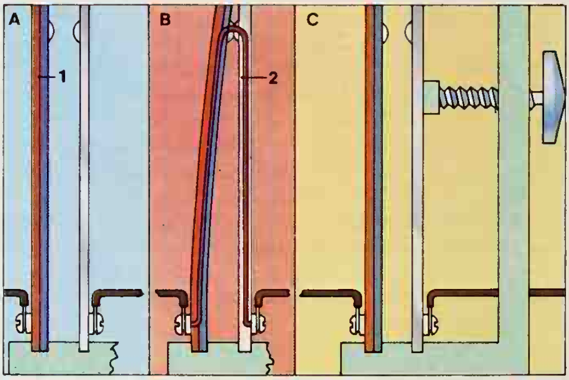
A clinical thermometer consists of a bulb of mercury (1) *in a glass stem* (2). *Body heat causes the mercury to expand through a constriction* (3) *into a capillary tube* (4), *where it is measured against a scale* (5). *The shape of the glass* (6) *acts as a magnifying lens to facilitate reading. Surface tension at the constriction keeps the mercury at its highest reading until shaken down by hand* (7).

thermonuclear reaction see FUSION, NUCLEAR; FUSION ENERGY; HYDROGEN BOMB

Thermopylae [thur-mahp'-uh-lee] Thermopylae is a pass in Greece lying between Mount Oeta and the Gulf of Malia's southern shore. Because of its strategic importance on the route from Thessaly to Locris, it was the site of three notable ancient battles. In 480 BC the Spartans under LEONIDAS heroically defended Thermopylae against Xerxes' Persians; in 279 BC the Greeks blocked the Gauls under BRENNUS for months; and in 191 BC, ANTIOCHUS III of Syria tried in vain to hold the pass against the Romans.

thermosphere The thermosphere is the highest and largest of the four atmospheric layers (see ATMOSPHERE). It extends from the mesopause (about 80 km/50 mi above sea level), where the average temperature is a low of about –80° C (–112° F), to the thermopause (about 600 km/375 mi above sea level), where the temperature may reach highs of 225° C (440° F) at night during a period of minimum solar activity, and 1,475° C (2,690° F) in the daytime during a period of maximum solar activity. The upper part of the thermosphere is warm, because it readily absorbs solar ultraviolet radiation, which has the additional effect of generating the ionosphere. The thermosphere is the only heterogeneous atmospheric layer. Vertical mixing takes place in the lowest 80 km (50 mi). Composition changes drastically at higher levels, with gravity pulling the heavier gases (oxygen and nitrogen) downward, thus leaving helium and hydrogen as the predominant gases in the upper reaches.

thermostat A thermostat is an electromechanical on/off switch that is activated by temperature changes. It is typically used to control a heating or cooling system. The sensing element is usually a spiral bimetallic strip that coils and uncoils in response to temperature changes because of differential expansion of the two bonded metals. The switch element is either a set of electrical contacts or a glass-encapsulated mercury switch that controls a low-voltage relay. The relay can actuate a motor starter and igniter for an oil burner, a heavy-duty switch for electrical units, or a solenoid-operated valve on a gas furnace. The thermostat may also control a house-type air conditioner or heat pump.



The thermostat in an electric air conditioner (A) *is operated by a bimetallic strip* (1) *that responds to changes in room temperature. The strip is welded from two metals that have different coefficients of thermal expansion. When the temperature rises* (B), *the outer metal expands faster than the inner one, causing the strip to bend toward a fixed contact* (2). *The connection completes an electric circuit that starts the air conditioner's motor. The distance between the contacts can be adjusted* (C) *to change the minimum operational temperature.*

Theroux, Paul [thur-oh'] The popular and prolific contemporary writer Paul Theroux, b. Medford, Mass., Apr. 10, 1941, bases much of his work on his long experience as an expatriate and traveler. Theroux's early career as a teacher in Malawi, Uganda, and Singapore gave him the background for many of his early novels—*Girls At Play* (1969), *Jungle Lovers* (1971), *Saint Jack* (1973; film, 1979), among others. The highly successful *Mosquito Coast* (1982; film, 1986) focuses on the American self-help tradition gone berserk in a tropical jungle. *O-Zone* (1986) is an apocalyptic novel of an A-bombed future. Theroux's nonfiction includes several books based on railroad expeditions (such as *The Great Railway Bazaar: By Train through Asia*, 1975). *The Kingdom by the Sea* (1985) is a rather bitter account of his journey on foot around Great Britain. Recent work includes the novel *My Secret History* (1989).

thesaurus [thuh-saw'-ruhs] A thesaurus, from the Greek for "storehouse" or "treasure," is a catalog of words and phrases designed to facilitate literary composition. Like a dictionary of synonyms, it groups related words together, but unlike such a dictionary it is arranged conceptually, with entries organized without regard to spelling. These headings are further divided according to meaning and parts of speech, so that the word *biased*, for example, might be found under the category "obliquity" (grouped with the related adjectives *leaning, beveled*, and *sloped*) and also under "narrow-mindedness" (along with *prejudiced, one-sided*, and *partial*). An alphabetical index lists entries.

The British cleric John Wilkins brought out a "conceptual dictionary," with tables, as early as 1668. The first successful example, however, was devised by Peter Mark Roget (1779–1869), a British physician who produced his *Thesaurus of English Words and Phrases* in 1852. Today, revised editions of *Roget's International Thesaurus* remain the standard by which other thesauri are judged.

Theseus [thee'-see-uhs] In Greek mythology Theseus was usually regarded as the hero who organized Athens into a city, became its first true king, and set it upon the path of civilization. The son of either Aegeus, king of Athens, or Poseidon and Aethra, Theseus was born and grew up in Troezen, in Argolis. On his way to Athens to claim his patrimony, he performed six labors; all but one involved killing robbers and murderers by their own methods. At last, Theseus arrived in Athens and was greeted by his father Aegeus and his stepmother Medea. Jealous of his influence over Aegeus, Medea tried to kill Theseus by sending him to rid the plain of Marathon of a wild bull; once Theseus had sacrificed the bull to Apollo, Medea tried to poison him. Aegeus saw through her plot, and Medea escaped to Asia.

Further adventures of Theseus were killing the Minotaur in Crete with the aid of Ariadne, whom he loved and later deserted at Naxos; becoming king of Athens upon the death of Aegeus and uniting the Attic communities into a single state; assisting Oedipus in his last, blind days; warring against the Amazons and abducting their queen, Hippolyta (or Antiope), by whom he had a son, Hippolytus; trying to kidnap Persephone from the underworld, for which Hades punished him by chaining him to a bench (Theseus was eventually rescued by Hercules); and marrying Phaedra, Ariadne's sister, who made improper advances toward Hippolytus and who, after falsely accusing Hippolytus, hanged herself. Banished from Athens after a descendant of an old king of Athens stirred up a conspiracy against him, Theseus went to Skyros, where King Lycomedes pushed him off a cliff to his death. Later, Cimon of Athens recovered the body of Theseus and reburied it in Athens.

Thespis [thes'-pis] Thespis (fl. 6th century BC) was an Attic poet traditionally regarded as the founder of Greek tragedy. Hardly anything is known of him, but he is believed to have introduced the role of an actor—the responder—separate from those of the chorus and chorus leader, which modified dithyrambic performance (exchanges between chorus and leader) by instituting spoken dialogue and thus inventing the drama. The word *thespian* (actor) is derived from his name.

Thessalonians, Epistles to the [thes-uh-loh'-nee-uhnz] The two Epistles to the Thessalonians, books of the New Testament of the Bible, are the first of Saint Paul's letters, written about AD 50 from Corinth to his recently founded community of Christians at Thessalonika. Paul reviews his stay with them, expresses concern for their welfare, and encourages them in suffering. Paul also instructs them on the Second Coming of Jesus, which he expected imminently at this early stage in his career, and reassures them that those already dead will rise and that certain signs will precede the end.

Thessaloníki see Salonika

Thessaly [thes'-uh-lee] A historic region in northeastern Greece, bounded by Macedonia to the north, the Aegean Sea to the east, and Epirus to the west, Thessaly is largely agricultural, producing grain, tobacco, and vegetables. Its major city is Lárisa.

The Thessali, a Dorian people from Epirus, conquered the region before 1000 BC and ruled through powerful military families. Philip II of Macedonia entered Thessaly in 353 BC and gradually subjugated the region by gaining control of the Amphictyonic League. Thessaly became a Roman protectorate in 197 BC and part of the province of Macedonia in 146 BC. Slavs, Arabs, Bulgarians, Normans, and Walachians invaded and settled Byzantine Thessaly between the 7th and 13th centuries. The region was ruled by the Turks from the end of the 14th century to 1881, when most of it was ceded to Greece.

Thetis [thee'-tis] In Greek mythology Thetis, mother of Achilles, was a sea goddess attended by the Nereids and beloved by both Zeus and Poseidon. Neither would marry her, however, because an oracle had decreed that she would bear a son mightier than his father. Thetis married King Peleus, and when Achilles was born, she resolved to make him invulnerable by dipping him into the River Styx. Only his heel, by which she held him, could thereafter be pierced successfully by a weapon.

Thibault, Jacques Anatole François see France, Anatole

Thiebaud, Wayne [tee'-boh] Wayne Morton Thiebaud, b. Mesa, Ariz., Nov. 15, 1920, is a figurative painter who became prominent during the mid-1950s for his thick, impasto paintings of subjects such as mass-produced food and household and workshop objects. Because of his use of such commercial subjects, Thiebaud has been mistakenly identified as a pop artist, but his naturalistic, varied images are more personal than the true pop style. In his more recent works Thiebaud concentrates on lushly painted figures of familiar American types dressed in typical department-store clothing.

Thiers, Adolphe [tee-air'] The French statesman and writer Louis Adolphe Thiers, b. Apr. 18, 1797, d. Sept. 3, 1877, was a founder and the first president of France's Third Republic. He began his career as a journalist and then wrote his celebrated *History of the French Revolution* (10 vols., 1823–27; Eng. trans., 5 vols., 1895). In 1830 he helped start the liberal daily *Le National*, which helped foment the July Revolution (1830) that brought Louis Philippe to the throne. Thiers served the new government in various positions, including foreign minister, through the 1830s. He resigned in 1840 and again wrote history, beginning a 20-volume study of Napoleon I, *History of the Consulate and the Empire* (1845–62; Eng. trans., 1845–62).

In 1848, Thiers was a member of both the constituent and legislative assemblies. Once classified as a liberal monarchist, he was now known as a conservative—and

Louis Adolphe Thiers helped found the Third Republic in France following the collapse of Napoleon III's regime during the Franco-Prussian War. As head of the provisional government he negotiated peace with the Prussians and ordered suppression of the Paris Commune (1871). He then served (1871–73) as first president of the republic.

chauvinistic—republican. He was banished in 1851 after Napoleon III's coup d'état. In 1863 he returned to politics as a deputy. A leader of the antiimperialists in the chamber, he repeatedly warned Napoleon III of the Prussian threat. Before the Franco-Prussian War (1870–71) he vainly tried to make mutual-defense agreements with other European countries.

After the Prussian victory and the collapse of the Napoleonic government in 1871, Thiers was chosen leader of the National Assembly. He made peace with the Prussians in March, in May he crushed the Paris Commune, and in August he became president of the new Republic. His prestige, ability, and will aided France's recovery. A monarchist victory in the 1873 by-elections forced his resignation; a monarchist, Patrice MacMahon, became the second president. Thiers then led the republican opposition until his death.

Thieu, Nguyen Van see Nguyen Van Thieu

Thimbu [thim-boo'] Thimbu (or Thimphu), the capital of Bhutan since 1962, lies in the Himalayas in the west central part of the country at an altitude of 2,425 m (7,950 ft). The population is 20,000 (1985 est.). A modern city, Thimbu developed around Bhutan's largest monastery, the red-roofed, fortified Tashichhodzong, which also serves as the meeting hall of the National Assembly. Rice, corn, and wheat grow in the surrounding area.

thin-film technology Thin-film technology makes it possible to deposit a very thin layer of material—down to a few atoms in thickness—upon a substrate (see epitaxy).

Thin films are important in microelectronics fabrication, in which ever-larger numbers of components are fitted onto the microchip. Protective plastic coatings can also be placed on microcircuits through thin-film deposition. Likewise, superconducting materials can be deposited on a substrate; the unique electronic behavior during superconductivity may eventually substantially reduce the processing time for microchips.

Thin-film technology has been used in the fabrication of more-efficient solar cells. Compact thin-film chemical sensors have been developed that can instantaneously detect substances, such as poison gases in air or impurities in blood, in concentrations of a few parts per billion. In the future, thin-film technology will be integral to the development of solid-state lasers and microchips that process information optically. Thin-film diamond layers may have many uses both as an abrasive and as a protective coating.

think tanks *Think tank* is an informal term used to refer to a particular type of research institution that began to proliferate in the United States after World War II. A think tank differs from other research institutions in that it concentrates its research on issues that relate to policy making.

A popular term to describe the work of think tanks is *policy research*, which consists of research that produces ideas analysis and alternatives relative to people who make policy. Think tanks are often employed by government agencies to work on military, social, technical, and economic problems.

Several other characteristics typify the work of a think tank. Generally, its approach is directed toward the future—that is, toward long-range planning; it is apt to use scientific methodologies; and it is invariably multidisciplinary. (See also futurology.)

thinking see problem solving; reasoning

3d Amendment see bill of rights; Constitution of the United States

Third Reich [ryk] Adolf Hitler's National Socialist (Nazi) regime in Germany (1933–45) called itself the Third Reich, a designation chosen to identify the Nazi Reich, or empire, as third in succession to the Holy Roman Empire and German Empire of 1871–1918.

Third Republic see France, history of

Third World In its most general sense, the term *Third World* refers collectively to more than 100 countries of Africa, Asia, and Latin America. The term emerged in Europe during the late 1940s, referring to a "third force," not aligned with either the Communist or Western blocs. In the 1950s it was occasionally used to describe the newly independent states of Asia and Africa. Latin American countries were not encompassed by the term at first because of their more distant colonial past and their close ties to the United States. By the early 1960s, when threats to U.S. hegemony were emerging in Latin America and European decolonization was accelerating in Africa, Third World acquired its present meaning. It also came to refer primarily to economic characteristics and was frequently adopted in preference to such words as *undeveloped, backward, traditional, nonwestern*, or *underdeveloped*, which had derogatory or misleading connotations.

Third World countries were generally distinguished from those of the first world (industrialized free-market economies) and second world (industrialized centrally planned economies) on the basis of indicators of industrial development, poverty, vulnerability to international economic conditions, and quality of life. The terms *less developed countries* (LDCs) and *developing countries* are commonly used by international organizations such as the United Nations and World Bank. Recently, economic differences among Third World countries have been increasing. Some have now acquired industrial status and are often called the "newly industrialized countries" (NICs), while others (sometimes called "fourth world" nations) are experiencing little economic growth, industrial or otherwise. With the rise of oil prices in the 1970s, the petroleum-exporting countries emerged as a new group of nonindustrial but nonetheless high-income Third World nations. The term "South" has also been used to characterize many Third World countries, as opposed to the industrialized nations of the "North."

See also: NONALIGNED MOVEMENT.

13th Amendment The 13th Amendment to the U.S. Constitution states that "neither slavery nor involuntary servitude" shall exist in the United States and gives Congress the power to enforce this article by legislation. Although this amendment, which was ratified in 1865, had been preceded by a federal restriction on the importation of slaves in 1808, by the EMANCIPATION PROCLAMATION of 1863, and by legislative bans against slavery in many of the states prior to 1865, the 13th Amendment was the first unconditional constitutional action to terminate the institution of slavery and the first of the amendments to protect the equal status of black people (others are the 14th, 15th, and 24th Amendments). The 13th Amendment has been interpreted by the Supreme Court to include prohibition of public or private racial discrimination in the disposal of property, in making and enforcing contracts, and in private employment.

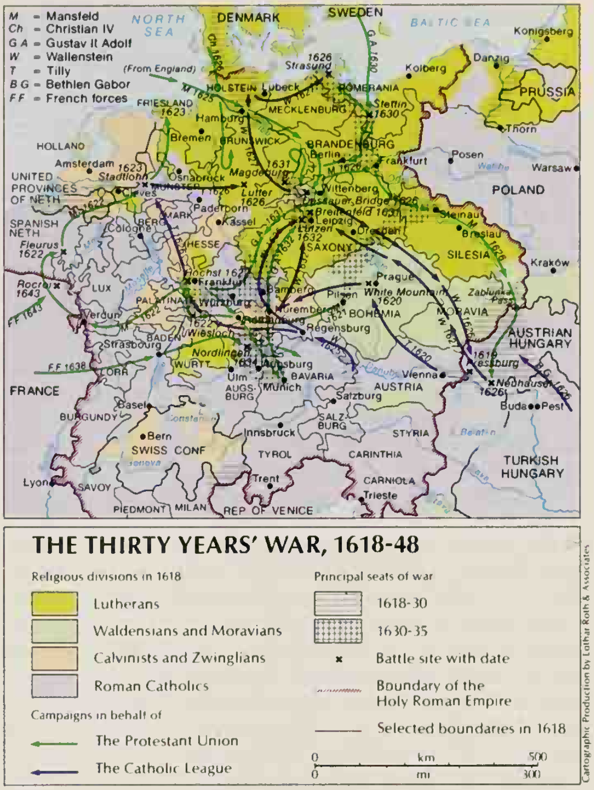
Although specifically directed against slavery, the ban against involuntary servitude ("except as a punishment for crime") has been viewed by the federal courts as applicable to other conditions of forced labor.

See also: CONSTITUTION OF THE UNITED STATES.

Thirty-nine Articles The basic summary of belief of the Church of England (see ENGLAND, CHURCH OF), the Thirty-nine Articles of Religion were drawn up by the church in convocation in 1563 on the basis of the earlier Forty-two Articles of 1553. Subscription to them by the clergy was ordered by act of Parliament in 1571. Devised to exclude Roman Catholics and Anabaptists, but not to provide a dogmatic definition of faith—in many instances, they are ambiguously phrased—the articles were influenced by the confessions of Augsburg and Württemberg (earlier statements of Protestant belief). They concern fundamental Christian truths (Articles 1–5), the rule of faith (Articles 6–8), individual religion (Articles 9–18), corporate religion (Articles 19–36), and national religion (Articles 37–39). Retained in use by the various churches of the ANGLICAN COMMUNION, the Articles have been changed only as circumstances require. Thus the Protestant EPISCOPAL CHURCH of the United States has retained them, without requiring assent, changing only those articles affected by the independence of the United States from England (Articles 36 and 37).

Thirty Years' War The Thirty Years' War (1618–48) was the last major European war of religion and the first all-European struggle for power. It was, in fact, a series of wars fought mainly on German soil and was only part of a larger struggle to alter the European balance of power.

The religious wars that had divided Germany and the Holy Roman Empire as a result of the Protestant REFORMATION ended in compromise with the Peace of Augsburg (1555), and there was peace between the Protestant and Roman Catholic states of the empire for the next 50 years. In the early 17th century, however, tensions between the rival faiths revived.



THE THIRTY YEARS' WAR, 1618-48

Cartographic Production by Lothar Roth & Associates

The Bohemian War. Hostilities broke out on May 23, 1618, when a number of Protestant Bohemian noblemen threw two royal governors of their country out of the windows of the Hradčany Palace in Prague (an event known as the Defenestration of Prague). It was a rebellion typical of this period by men of great privilege and power who saw a threat in the advance of royal power: in this case in the absolutist and Catholic policies of their king, Ferdinand of HABSBURG, soon to be elected Holy Roman Emperor FERDINAND II. Both sides looked for allies and widened the conflict, entangling it with the religious and political struggles of their neighbors.

The Bohemians appealed to Gábor BETHLEN, Protestant prince of Transylvania, who, with the encouragement of his overlord, the Ottoman sultan of Turkey, was hoping to win the crown of Hungary from the Habsburgs. They also elected FREDERICK V of the Palatinate as their new king. They hoped that Frederick's father-in-law, JAMES I of England, and his uncle, MAURICE OF NASSAU, virtual ruler of the United Provinces of the Netherlands, would lend him support.

Ferdinand called on Poland but especially on his cousins Maximilian, duke of Bavaria (leader of the Catholic League of German princes), and on the Habsburg king of Spain, Philip III. On Nov. 8, 1620, Maximilian's general, Graf von Tilly, defeated the Bohemians at White Mountain near Prague, and Frederick lost his crown as suddenly as he had won it. He continued to fight, employing various mercenary leaders, including Ernst, Graf von Mansfeld, and relying on some English and a great deal of Dutch help. In 1623, however, the Palatinate was overrun by Spanish and Bavarian troops, and Frederick's electoral vote was transferred to Maximilian of Bavaria.

Expansion of the War. In 1621 the Dutch and Spanish had renewed the war that had started two generations previously with the revolt of the Netherlands (see Dutch Revolt). This struggle remained an important factor in the Thirty Years' War. It ranged to the Caribbean, the South Atlantic, and the Indian Ocean. The Dutch captured the Gold Coast, parts of Angola, and half of Brazil from the Portuguese, only to lose Angola and Brazil to Portugal in 1640.

In Europe Spanish troops fought in Germany, Italy, and France. The Dutch preferred to finance military allies. After Frederick's generals these allies included, first, Christian IV of Denmark, who feared the continued victories of Tilly's armies. In April 1626, Mansfeld met defeat at Dessau Bridge by a new imperial army raised by a wealthy and ambitious former Protestant Bohemian, Albrecht von Wallenstein. Four months later Christian was routed by Tilly at Lutter am Barenberge. With victory apparently in hand, Emperor Ferdinand issued (Mar. 29, 1629) the Edict of Restitution, which restored to the Catholic church all property taken by the Protestants since 1552.

After Denmark's withdrawal (May 1629) from the war, however, another Scandinavian power joined the fray. Encouraged by France, Sweden concluded a truce with its Baltic rival Poland, and in July 1630 the Swedish king Gustav II Adolf landed in Pomerania to begin a series of victorious campaigns against the imperial armies. At Breitenfeld (Sept. 17, 1631) and at the Lech River (Apr. 15, 1632) he defeated Tilly, and at Lützen (Nov. 16, 1632) the Swedes defeated Wallenstein, although Gustav Adolf was killed.

The Peace of Westphalia, concluded in 1648 after 5 years of negotiations, ended the Thirty Years' War and effectively destroyed the Holy Roman Empire. (National Gallery, London.)

Throughout these years, the Catholic King Louis XIII of France, the traditional rival of the house of Habsburg for preeminence in Europe, had observed Tilly's and Wallenstein's victories with increasing concern, although he had waged several civil wars against his own Protestant subjects, the Huguenots. France turned to fight Spain, with only partial success, in northern Italy. After Gustav Adolf's death and after the Swedes suffered a severe defeat at Nördlingen (Sept. 6, 1634), France openly declared (1635) war on Spain, in alliance with the United Provinces, Sweden, and some German Protestant princes.

The ring of alliances was virtually complete; no treaty between any two states, or even group of states, could now end the war. The intervention of France on the "Protestant" side cut across the religious alignments of the combatants. More and more, religious motivation and aims dropped into the background. In 1640 both Catalonia and Portugal rebelled against Spain, although all three were Catholic. In 1643 the Protestant Christian of Denmark, fearing the increasing power of Protestant Sweden, restarted the old Danish-Swedish rivalry for the control of the Sound (Öresund), the northwestern entrance to the Baltic. Once more the Danes were heavily defeated and lost their monopoly control over the Sound.

Peace Settlements. From 1643 the ambassadors of the combatants met in peace congresses in the Westphalian cities of Münster and Osnabrück. It took 5 years to conclude peace—in January 1648 between Spain and the United Provinces and in October 1648 between France, Sweden, the Holy Roman emperor, and the German princes (see Westphalia, Peace of). The war between France and Spain continued until 1659 (Peace of the Pyrenees), with Britain joining France against Spain in 1656; the wars between Sweden and Poland and between Sweden and Denmark were not settled until 1660 (Peace of Oliva and Peace of Copenhagen).

The Peace of Westphalia solved some problems. The Habsburgs had failed to reassert imperial power, and the German princes were left with virtual political independence and with the right to choose their religion. Their subjects were given no such choice but were allowed to emigrate. In European power politics, religion no longer determined alliances, nor did it lead countries into war. Sweden had become the dominant power in the Baltic, and France had displaced Spain as the dominant power in western Europe.

The common people bore the real cost of the war. In Brandenburg, Mecklenburg, Pomerania, the Palatinate, Württemberg, and parts of Bavaria, civilian population losses may have been 50 percent or more.

thistle Thistle is the common name used to refer to several genera (notably *Cirsium*) of the family Compositae. These spiny herbaceous plants, native to the Northern Hemisphere, are characterized by dense heads of small white, yellow, red, or purple flowers. Creeping Canada thistle, *C. arvense*, is a noxious, ubiquitous, prickly perennial North American weed. It is able to reproduce itself from root fragments, and plowing it under spreads rather than kills it. At times, however, it is grown for display because of its stark natural beauty. On the other hand, the Scotch, or cotton, thistle, *Onopordum acanthium*, can make an attractive garden plant.

Thomas, Clarence Clarence Thomas, b. Savannah, Ga., June 23, 1948, became an associate justice of the U.S. Supreme Court in 1991, replacing retiring Justice Thurgood Marshall after a bruising Senate confirmation battle. Thomas grew up in the rural hamlet of Pin Point, Ga., and was educated at an all-black Roman Catholic school in Savannah. After abandoning studies for the priesthood, he graduated from Holy Cross College in Worcester, Mass., in 1971 and from Yale Law School in 1974. A conservative Republican, he worked for Missouri Attorney General John Danforth, first as a prosecutor and, after Danforth's election to the U.S. Senate, as a legislative assistant. President Ronald Reagan named Thomas to head the Equal Employment Opportunity Commission (1982–89), and in 1989, President George Bush named him to the U.S. Court of Appeals for the District of Columbia.

Thomas, Saint One of the original 12 apostles of Jesus Christ, Thomas, called Didymus, refused to believe in the testimony of the other apostles concerning the resurrection of Jesus until he saw the wounds of the resurrected Christ himself (John 20:24, 25, 26–29). From this comes the expression "doubting Thomas."

Eusebius of Caesarea records that Thomas became a missionary to Parthia. The *Acts of Thomas* (3d century), however, states that he was martyred in India. The MALABAR CHRISTIANS claim that their church was founded by him. Saint Thomas's Mount in Madras is the traditional site of his martyrdom. Feast day: July 3 (Western and Syrian); Oct. 6 (Eastern).

Thomas, Dylan One of the best-known British poets of the mid-20th century, Dylan Marlais Thomas, b. Swansea, Wales, Oct. 27, 1914, d. Nov. 9, 1953, is remembered for his highly original, obscure poems, his amusing prose tales and plays, and his turbulent, well-publicized personal life. His most popular works include the radio play *Under Milk Wood* (posthumously published, 1954) and the sketch "A Child's Christmas in Wales" (1955), but his more ambitious work consists of the complex poems in which he expressed a deeply romantic vision. His ability to re-create the innocence of childhood through adult eyes was surpassing.

Thomas's first book of verse, *18 Poems* (1934), was praised by a few discriminating critics in spite of its obscurity, and in 1936 a second volume, *Twenty-Five Poems*, followed. Thomas married in 1937 and lived with his wife, Caitlin, in poverty in England and Wales. During this period he began to write short stories. His main prose works include *Portrait of the Artist as a Young Dog* (1940), a collection of autobiographical short stories; *Adventures in the Skin Trade* (1955); and *Quite Early One Morning* (1954), a collection of radio talks.

Dylan Thomas, a 20th-century Welsh poet, expressed a resilient innocence and love of life in such poems as "Fern Hill" and "Do Not Go Gentle into That Good Night." Widely known for his poetry readings over BBC radio, he became a popular, if controversial, figure. He died at the age of 39.

Rejected for military service during World War II, Thomas became relatively prosperous as a writer of radio scripts and films. He also published *The Map of Love* (1939), a volume of poems and fantastic short stories, and *Deaths and Entrances* (1946), another book of verse. Beginning in 1949, Thomas visited the United States several times, touring college campuses to read his poetry. His erratic behavior, however, showed that he suffered from mental disturbances, and he died in New York City after a period of depression and heavy drinking.

Thomas, George Henry Union general George Henry Thomas, b. Southampton County, Va., July 31, 1816, d. Mar. 28, 1870, achieved fame for his victories in the western campaigns during the U.S. Civil War. After graduating (1840) from the U.S. Military Academy, he served in the Mexican War and taught (1851–54) at West Point. Thomas earned the epithet Rock of Chickamauga after his strong defenses at the Battle of CHICKAMAUGA, in Tennessee, where he held the Confederates at bay (Sept. 19–20, 1863) until reinforcements arrived permitting the Federals an orderly withdrawal. Promoted to brigadier general and given command of the Army of the Cumberland, he played a key role in the Union victory at Chattanooga (November 1863; see CHATTANOOGA, BATTLES OF). At Nashville (Dec. 15–16, 1864) Thomas halted Confederate forces under Gen. John B. HOOD that threatened to cut the Federals' communications lines. Thomas later commanded military governments in Kentucky and Tennessee and the Division of the Pacific.

Thomas, Isaiah The leading printer of his day, Isaiah Thomas, b. Boston, Jan. 19, 1749, d. Apr. 4, 1831, was also an early patriot. His paper *The Massachusetts*

Spy (founded 1770) so angered the Tories that he moved it to Worcester, Mass., during the American Revolution. Thomas opened a bookstore with several branches, published *The Massachusetts Magazine* (1789–96), and in 1812 founded The American Antiquarian Society, to which he left land, a building, a large library, and substantial funds. His *History of Printing in America* (1810) contains accurate records of prices, processes, paper, and equipment.

Thomas, Lewis American medical administrator and author Lewis Thomas, b. Flushing, N.Y., Nov. 25, 1913, is best known for his philosophical essays on biology and human society. Thomas earned an M.D. from Harvard Medical School (1937) and held posts at Bellevue Medical Center, Yale University, and elsewhere. From 1973 to 1980 he served as president at Sloan-Kettering Cancer Center in New York City. His *The Lives of a Cell* (1974) won the National Book Award; other collected essays include *Medusa and the Snail* (1979) and *Late Night Thoughts while Listening to Mahler's Ninth Symphony* (1983).

Thomas, Lowell A radio news broadcaster for 46 years, Lowell Thomas, b. Woodington, Ohio, Apr. 6, 1892, d. Aug. 29, 1981, wrote more than 50 books about his travels and adventures. He grew up in the gold-mining community of Cripple Creek, Colo., and began his career as a newspaper reporter after graduating from the University of Denver. During World War I he reported from Europe and the Near East and did much to establish the legend of T. E. Lawrence—Lawrence of Arabia.

Lowell Thomas, an American newcaster and journalist, studies wire-service reports prior to his nightly radio program. Thomas's career, spanning six decades, included exclusive coverage of T. E. Lawrence's Middle East campaign and the narration of innumerable wartime newsreels.

Thomas, Martha Carey Martha Carey Thomas, b. Baltimore, Md., Jan. 2, 1857, d. Dec. 2, 1935, serving (1894–1922) as the autocratic president of Bryn Mawr College, made that school the rival of the most prestigious men's colleges by establishing ultrademanding academic standards. Under her guidance the Summer School for Women in Industry offered educational opportunities to working-class women. An activist in the drive for women's suffrage, she early supported the Equal Rights Amendment.

Thomas, Michael Tilson American conductor Michael Tilson Thomas, b. Hollywood, Calif., Dec. 21, 1944, in 1969 became Boston Symphony Orchestra's youngest associate conductor. From 1971 to 1979 he served as music director of the Buffalo Philharmonic; he has since held guest-conducting posts. Thomas led the first American performances (1979) of the three-act version of Alban Berg's opera *Lulu* at the Santa Fe Opera.

Thomas, Norman Norman Mattoon Thomas, b. Marion, Ohio, Nov. 20, 1884, d. Dec. 19, 1968, was six times an unsuccessful SOCIALIST PARTY candidate for president of the United States between 1928 and 1948. A Presbyterian minister in East Harlem's slums, he became a pacifist and opposed American entry into World War I. In 1917 he helped found what became the American Civil Liberties Union. Thomas joined the Socialist party in 1918 and became its leader in 1926, espousing a moderate, non-Marxist brand of socialism.

Thomas worked against U.S. support for the Allies in World War II, but after Pearl Harbor, he gave the war effort critical support. He protested the internment of Japanese Americans and the postwar political prosecution of Communists. Thomas backed the Korean War in the early 1950s but opposed U.S. intervention in Indochina in the 1960s. His socialism gradually became diluted by his advocacy of a mixed economy.

Norman Thomas, leader of the U.S. Socialist party from 1926 to 1955, was six times (1928, 1932, 1936, 1940, 1944, and 1948) an unsuccessful candidate for the presidency of the United States. A moderate socialist, Thomas was widely respected for his idealism and persistence.

Thomas, Seth Seth Thomas, b. Wolcott, Conn., Aug. 19, 1785, d. Jan. 29, 1859, was a U.S. manufacturer who pioneered in the mass production of clocks. In 1807, Thomas, an apprentice carpenter, joined Eli Terry and Silas Hoadley, two Connecticut clockmakers, in founding a manufacturing firm that in 3 years had produced 4,000 clocks. In 1812, Thomas launched his own factory, and 2 years later he began to produce shelf clocks with wooden works, inexpensively and in large quantities. He then built (1838) a mill to roll brass and make wire in order to manufacture brass clock movements. The Seth Thomas Clock Company was formally organized in 1853.

Thomas à Kempis The probable author of the devotional treatise *The Imitation of Christ*, Thomas à Kempis, b. Kempen, Germany, *c.*1380, d. Aug. 8, 1471, was influenced by the tradition of Gerhard GROOTE and the Brethren of the Common Life. Thomas entered a monastery of the Augustinian canons and was ordained in 1413. *The Imitation of Christ* embodies many of the key ideas of the *devotio moderna:* stress on being faithful to the movements of grace, on poverty and humility, and on guarding against temptations.

Thompson, Daley Great Britain's Francis Morgan "Daley" Thompson, b. July 30, 1958, is only the second man in Olympic history to win two decathlons (1980, 1984; American Bob Mathias won in 1948 and 1952). Unbeaten in his event from 1978 to 1987, Thompson set the world record—8,847 points—in 1984. His bid for an unprecedented third Olympic gold medal in Seoul in 1988 was unsuccessful.

Thompson, David David Thompson, b. London, Apr. 30, 1770, d. Feb. 10, 1857, the greatest 19th-century surveyor in North America, explored vast areas that later became part of western Canada and the northwestern United States. Apprenticed to the HUDSON'S Bay Company at age 14, he spent several years at various company posts and learned surveying. In 1796 he blazed a new route to Lake Athabasca, traveling from York Factory by way of the Nelson, Burntwood, and Churchill rivers and Reindeer Lake to Fond du Lac. Dissatisfied with his employers, he joined the NORTH WEST COMPANY in 1797, becoming a partner in 1804.

For the North West Company, Thompson surveyed (1797–98) the Mississippi's headwaters, crossed (1807) the Canadian Rockies by the Howse Pass to the source of the Columbia, explored (1808–10) Washington, Idaho, and Montana, and became the first white person to travel (1811) the Columbia's entire length. Everywhere, he made observations that, after retirement in 1812, enabled him to complete a map (1813–14) that became the basis for all subsequent maps of western Canada. He surveyed (1816–26) the Canada-U.S. boundary between the St. Lawrence River and Lake of the Woods for the International Boundary Commission.

Thompson, Dorothy The American journalist Dorothy Thompson, b. Lancaster, N.Y., July 9, 1894, d. Jan. 31, 1961, went to Europe in 1920 with no job and little money; her ingenuity and a knack for being where the news was gained her a position as foreign correspondent with the *Philadelphia Public Ledger* and *New York Evening Post.* She became head of the *Ledger* and *Evening Post*'s Berlin office in 1925 but was expelled from the country in 1934 for speaking out against Hitler. Her column "On the Record" ran from 1936 until 1958; selections from it appeared in *Let the Record Speak* (1939).

Thompson, Sir John Sparrow David The lawyer and politician Sir John Sparrow David Thompson, b. Nova Scotia, Nov. 10, 1844, d. Dec. 12, 1894, was prime minister of Canada in 1892–94. A Liberal-Conservative, he became Nova Scotia's prime minister (1882) before sitting on the provincial Supreme Court (1882–85). He was minister of justice (1885–91) in John A. Macdonald's federal administration before winning the position of prime minister.

Sir John S. D. Thompson was Conservative prime minister of Canada from 1892 until his death in 1894. He had previously held the positions of prime minister of Nova Scotia and minister of justice for Canada.

Thompson, Randall The composer and educator Randall Thompson, b. New York City, Apr. 21, 1899, d. July 9, 1984, is best known for his choral works, particularly *The Testament of Freedom* (1943) for men's voices and orchestra (or piano), and *Alleluia* (1940) for unaccompanied chorus. He studied at Harvard and then privately with Ernest Bloch. He was a Fellow (1922–25) of the American Academy in Rome and a director (1939–41) of the Curtis Institute in Philadelphia, and he taught at various universities, including Harvard (1948–65). He also wrote orchestral works (including three symphonies) and chamber music (including two string quartets).

Thompson, William Hale William Hale Thompson, called Big Bill, b. Boston, May 14, 1867, d. Mar. 19, 1944, was a colorful Republican machine leader who served three terms (1915–23, 1927–31) as mayor of Chicago. His political career was marked by both his rabid anti-British sentiments and his inability or unwillingness to prevent the open operation of criminal gangs.

Thomsen, Christian Jürgensen Christian Jürgensen Thomsen, b. Dec. 29, 1788, d. May 21, 1865, was the Danish archaeologist who evolved the Stone, Bronze, and Iron three-age system of PREHISTORY. He served (1816–65) as the first curator of the Museum of Northern Antiquities, later the National Museum in Copenhagen. His arrangement of the antiquities in the collection showed a practical example of this system, and this method was recognized to be of great value in interpreting the prehistoric past.

Thomson, Charles Charles Thomson, b. County Londonderry, Ireland, Nov. 29, 1729, d. Aug. 16, 1824, was a Pennsylvania patriot leader in the era of the American Revolution and secretary of the Continental Congress (1774–89). He arrived in America as an orphan in 1739 and became a prosperous Philadelphia merchant. His strong opposition to British policies led John Adams to call him "the Sam Adams of Philadelphia." Thomson helped secure Pennsylvania's approval for the meeting of the First Continental Congress in 1774. Although the colony's conservatives blocked his election as a delegate, he was able to participate because the Congress chose him as its secretary.

Thomson, James The Scottish poet James Thomson, b. Sept. 11, 1700, d. Aug. 27, 1748, best known as author of the immensely popular blank-verse poem *The Seasons* (1730), also wrote tragedies and the Spenserian epic *The Castle of Indolence* (1748). He traveled to London in 1725 and a year later published *Winter*, the first of his four season poems. As the initiator of a new descriptive mode in poetry, Thomson anticipated a key feature of 19th-century romanticism.

Thomson, Joseph Joseph Thomson, b. Feb. 14, 1858, d. Aug. 2, 1895, was a Scottish explorer of Africa. Having studied geology at the University of Edinburgh, he led an expedition for the Royal Geographical Society to Lakes Tanganyika and Rukwa in 1879–80. In 1883–84 he became the first white to cross modern Kenya, visiting Lake Baringo and seeing Mount Kenya before reaching Lake Victoria.

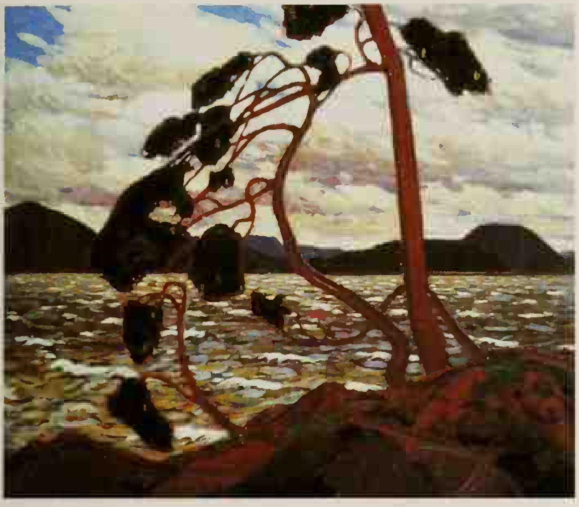
In 1885, Thomson was in northern Nigeria, where he concluded commercial treaties with some of the leaders of the emirates. In 1890, Cecil RHODES sent him to win Katanga for the British South Africa Company, but instead he gained mining and administrative rights for Britain in what is now Zambia.

Thomson, Sir Joseph John Sir Joseph John Thomson, b. Dec. 18, 1856, d. Aug. 30, 1940, is universally recognized as the British scientist who discovered and identified the electron. At the age of 27 he succeeded (1884) Lord Rayleigh as professor of physics at Trinity College, Cambridge, and was named director of its Cavendish Laboratory in the same year, continuing in that position until 1919. Thomson demonstrated (1897) that CATHODE RAYS were actually units of electrical current made up of negatively charged particles of subatomic size. He believed them to be an integral part of all matter and theorized a model of atomic structure in which a quantity of negatively charged electrons was embedded in a sphere of positive electricity, the two charges neutralizing each other. For these investigations he won (1906) the Nobel Prize for physics; in 1908 he was knighted.

Subsequently, Thomson turned his attention to positively charged ions. His research showed that neon gas was made up of a combination of two different types of ions, each with a different charge, or mass, or both. He did this by using magnetic and electric fields to deflect the stream of positive ions of neon gas onto two different parts of a photographic plate. This demonstration clearly pointed to the possibility that ordinary elements might exist as isotopes (varieties of atoms of the same element, which have the same atomic number but differ in mass).

Sir Joseph John Thomson, a pioneer in modern physics, discovered the electron in 1895, revolutionizing existing theories of atomic structure. Thomas is also recognized for his investigations into the conduction of electricity through gases—which earned him the 1906 Nobel Prize for physics.

Thomson, Tom The best-known Canadian landscape painter of his time, Tom Thomson, b. Claremont, Ontario, Aug. 4, 1877, d. July 1917, made his first trip to the untouched forests and lakes of Algonquin Park in northern Ontario in 1912. This region provided him with his major themes, expressed in his most famous work, *The West Wind* (1916–17; Art Gallery of Ontario, Toronto), in which humanity's struggle with nature is symbolized by a lone pine bent fiercely against a gale. Also evident is Thomson's lively, expressive brushwork and vibrant color-



The bold forms and vivid colors of Tom Thomson's The West Wind *(1916–17) are characteristic of his style. The beauty, grandeur, and isolation of northern Canada pervades Thomson's landscapes. (Art Gallery of Ontario, Toronto.)*

ation, which often led him close to abstraction. His wilderness subjects had great influence on later Canadian landscape painters, especially the GROUP OF SEVEN.

Thomson, Virgil The American composer and critic Virgil Thomson, b. Kansas City, Mo., Nov. 25, 1896, d. Sept. 30, 1989, attended Harvard University, and while there he obtained a traveling fellowship (1921–22) to study with Nadia Boulanger in Paris. Study with Boulanger was a fruitful experience for many American composers of his generation and for Thomson prompted a return to Paris in 1925. During these Parisian sojourns he associated with Erik Satie, with the group of French composers known as Les Six, and with the writers Jean Cocteau and Gertrude Stein, all of whom influenced his work. Thomson's first opera, *Four Saints in Three Acts* (1928; libretto by Gertrude Stein), and many of his other works show aspects akin to the Dada movement in French art of the 1920s. A number of his works were inspired by the theater. His other works include the operas *The Mother of Us All* (1947) and *Lord Byron* (1972), *Symphony on a Hymn Tune* (1928), choral works, chamber music, songs, film scores, and piano and organ pieces.

Early in the 1920s, Thomson began writing music reviews for *Vanity Fair* and the *Boston Transcript*. When he settled permanently in New York in 1940 he became music critic (until 1954) for the *New York Herald Tribune*. He also wrote several books about music and an autobiography.

Thomson, William see KELVIN, WILLIAM THOMSON, 1ST BARON

Thor (mythology) [thohr] In Norse mythology Thor was the personification of thunder and the principal war god. He was the son of the chief god, ODIN, and second only to him in importance. He was armed with a hammer (Mjolnir) that returned to his hand after he hurled it at enemies, a belt that doubled his strength when he wore it, and iron gloves that helped him use the Mjolnir effectively. Most of his battles were fought against giants, and he was benevolent to humankind. Thor was noted for his ability to drink vast amounts; he is generally portrayed as a crude, red-bearded, middle-aged warrior who relied on his immense strength rather than on his wits.

According to one popular legend, the giant who constructed the residence of the gods was rewarded with the Mjolnir. When it fell into the giant Thrym's possession, Thor retrieved it by pretending to be the goddess FREYA, whom Thrym demanded as his wife in exchange for the hammer.

Thor, also known as Atli, is identified with Donar, the thunder god of Teutonic mythology. His name survives in the English weekday name *Thursday* and in its German counterpart, *Donnerstag*.

Thor (rocket) Thor was an intermediate-range ballistic missile (IRBM) developed by the United States in the mid-1950s to provide the first element of a nuclear deterrent against the Soviet missile challenge (see ROCKETS AND MISSILES). It was later adapted for use as a space rocket.

The Thor missile stood 19.8 m (65 ft) tall and was fueled with liquid oxygen and kerosene. The lift-off weight was about 49,900 kg (110,000 lb). A single, gimbal-mounted rocket engine delivered a thrust of about 667,000 newtons (68,040 kg/150,000 lb) at sea level. A blunt heat shield protected a thermonuclear warhead.

This American Thor-Delta rocket was used to boost the European HEOS 1 satellite into orbit in 1968. The Thor-Delta, a three-stage solid-propellant rocket, was first launched in 1960 and is a variation of the earlier Thor, a liquid-fuel intermediate-range ballistic missile.

Guidance depended on a preset inertial system. Range was 2,780 km (1,725 mi).

After a series of four unsuccessful launches in 1957, the first satisfactory flight of the Thor occurred on September 20 of that year; it first flew with its guidance system in December.

In conjunction with upper stages such as AGENA, DELTA, and Able, the modified Thor has been used to launch many U.S. satellites and space probes. The thrust-augmented Thor (TAT) boosted thrust to 1,470,000 newtons (150,000 kg/330,000 lb).

thorax see CHEST

Thoreau, Henry David [thohr'-oh or thuh-roh'] The writer and naturalist Henry David Thoreau, b. Concord, Mass., July 12, 1817, d. May 6, 1862, is best known for WALDEN, an account of his experiment in simple living, and for the essay "Civil Disobedience" (1849), whose doctrine of passive resistance influenced Mahatma Gandhi and Martin Luther King, Jr.

The Journal. Raised in genteel poverty, Thoreau graduated from Harvard in 1837 and returned to Concord, there becoming a close friend of Ralph Waldo EMERSON's and other transcendentalists. With Emerson's encouragement, Thoreau continued with a journal that he had begun in 1834. It was conceived as a literary notebook, but it gradually developed into a work of art in its own right. Eventually reaching more than 2 million words, it ran to 14 volumes when published in 1906. Thoreau also published essays, poems, and reviews in various magazines, including Emerson's *The Dial*, whose editorship he assumed briefly in 1843 when Emerson was away.

Walden. In 1845, Thoreau, permanently established in the neighborhood of Concord, built a small cabin on Emerson's land near Walden Pond and lived there for two years. His purpose in going to the pond was to simplify his life, reduce his expenses, and devote his time to writing and observing nature. Out of his experiment came two books, *A Week on the Concord and Merrimack Rivers* (1849), the description of a rowboat excursion he had taken with his brother in 1839, and *Walden* (1854).

In July 1846, a year after moving into his cabin, Thoreau refused to pay his poll tax as a protest against American slavery and went to jail. Freed the next morning when an aunt, over his objections, paid the tax, he wrote "Resistance to Civil Government," later better known as "Civil Disobedience." In it he emphasized personal ethics and responsibility, urging the individual to follow the dictates of conscience in any conflict between it and the civil law and to violate unjust laws to effect their repeal.

Travels and Nature Study. Unable to support himself through his writing, Thoreau worked for a time as a laborer, including a stint in his family's pencil factory, and as a surveyor. During this period in the latter 1850s, he traveled extensively, recounting his excursions in essays on Cape Cod (1865), Quebec (1866), and the Maine wilderness (1864).

For most of his adult life Thoreau spent a large part of each day examining the flora and fauna of Concord. The journal records of his observations are among the most complete for any American locale, and his essay *Succession of Forest Trees* (1860) is a major contribution to natural history. At the time of his death he was engaged in a massive study of native fruits and seeds.

Henry David Thoreau expressed his principles through symbolic action as well as the written word, seeking the simplicity of nature at Walden Pond and affirming the primacy of the individual conscience by refusing to pay his taxes. His accounts of these actions in Walden *(1854) and "Civil Disobedience" (1849) are only part of his corpus of writings.*

Place in American Thought. In his lifetime often dismissed as an imitator of Emerson, Thoreau has slowly won an independent reputation as one of America's greatest prose stylists; as a naturalist, pioneer ecologist, and conservationist; as an advocate of the simple life; and as a proponent of democratic individualism. A visionary humanist, he gave perhaps the best summary of his thought in *Walden*'s succinct and yet profound injunction, "Simplify, simplify."

Thorfinn Karlsefni [thohr'-fin kahrl'-sev-nee] Thorfinn Karlsefni, an Icelandic explorer, attempted (*c.*1010) to found a settlement in North America soon after LEIF ERIKSSON's voyage there. According to two Icelandic sagas, Thorfinn was a wealthy trader who led a Viking expedition to the territory called VINLAND, in North America, and wintered there. The Scandinavians, both men and women, traded and then fought with the native Skraelings (roughly, "savages"). The descriptions of Skraeling culture in the sagas are consistent with American Indian life. Because of Skraeling attacks, the settlement was abandoned after three winters. Its location, like that of the earlier Viking settlements, is a matter of scholarly debate; L'ANSE AUX MEADOWS is one possible site.

thorium [thohr'-ee-uhm] The element thorium is a radioactive metal of the ACTINIDE SERIES of the PERIODIC TABLE. Its symbol is Th, its atomic number is 90, and the atomic weight of its stablest isotope is 232.038. Thorium was discovered in 1828 by J. J. Berzelius. Because it can be converted into fissionable uranium-233 in a BREEDER REACTOR, it may become an important source of atomic fuel. Thorium is also used in one type of RADIOMETRIC AGE-DATING technique.

Thornburgh, Dick Richard Lewis Thornburgh, b. Carnegie, Pa., July 16, 1932, became U.S. attorney general in 1988 under Ronald Reagan and continued in that position under George Bush. A graduate of Yale University (B. Engineering, 1954) and the University of Pittsburgh (LL.B., 1957), he was U.S. attorney for western Pennsylvania (1969–75), assistant U.S. attorney general (1975–77), and a Republican governor of Pennsylvania (1979–87).

Thorndike, Edward L. Edward Lee Thorndike, b. Williamsburg, Mass., Aug. 31, 1874, d. Aug. 9, 1949, was a major figure in several fields of psychology: learning theory, applied psychology, and mental measurement. First influenced by William James at Harvard, he studied at Columbia University and taught there from 1909 to 1940. His learning theory, applied to animals and human beings, added the principle of effect (success, pleasure, satisfaction) to Hermann Ebbinghaus's principle of exercise. Thorndike rid his theories of the mentalism of earlier psychologists and paved the way for the BEHAVIORISM of John B. WATSON. Thorndike published about 500 books and articles, including his thesis *Animal Intelligence* (1898), *Educational Psychology* (1903, later in three volumes), and *Mental and Social Measurements* (1904), and was president of the American Psychological Association.

Thoroughbred The Thoroughbred is a breed of horse developed for speed and elegance in racing. Some Thoroughbreds are also used for hunting and polo. About 16 hands (1.6 m/64 in) tall, the animals weigh from about 455 to 680 kg (1,000 to 1,500 lb) and have short, slim bodies with long muscles and long, strong legs. The head is delicate, somewhat like that of an Arabian horse. A Thoroughbred's speed depends on its individual ability, track conditions, weight carried, and distance run. The horses are high-spirited and nervous, and some tend to develop unsoundness of wind and limb. In the United States, Thoroughbreds are often bay colored but may also be chestnut, gray, roan, brown, or black.

The Thoroughbred is a light horse of superior speed and stamina used for flat racing, the steeplechase, hunting, and polo.

All Thoroughbreds are descended from three Oriental stallions—Godolphin Barb, Darley Arabian, and Byerly Turk—imported into England between 1689 and 1724. The stallions were bred with English mares having a strong mixture of Arabian, Turk, and Barb blood and soon produced progeny that grew to be as much as 20 cm (8 in) taller than their sires. A son of Darley Arabian, Bulle Rock, was imported into Virginia in 1730; soon other Thoroughbreds were brought to America. The most famous U.S. Thoroughbred was Man O'War (1917–47), who suffered only 1 defeat in 21 races.

Thorpe, Jeremy [thohrp] British politician John Jeremy Thorpe, b. Apr. 29, 1929, educated at Eton and Oxford, served (1967–76) as leader of the Liberal party, which was able to poll a postwar high of 19.3 percent of the votes cast in the general election in the spring of 1974. Thorpe's seemingly brilliant political future was shattered when a scandal erupted in 1976, involving a charge that he conspired to murder an alleged homosexual lover, Norman Scott. Thorpe resigned as leader of the Liberal party and was arrested in 1978. Acquitted in 1979, Thorpe ran unsuccessfully to regain his parliamentary seat.

Thorpe, Jim James Francis Thorpe, b. Prague, Okla., May 28, 1888, d. Mar. 28, 1953, was an American athlete who was selected by sportswriters as the greatest athlete of the first half of the 20th century. Thorpe, who was of American Indian, Irish, and French descent, played football at the Carlisle (Pa.) Indian School and was an All-American in 1911 and 1912. While at Carlisle, he also played lacrosse and baseball and ran track. In the 1912 Olympic Games, Thorpe set records in winning the decathlon and the pentathlon. In 1913 he was stripped of his gold medals when it was learned that he had earned money playing baseball. Thorpe started playing professional football in 1915 for the Canton Bulldogs, and in ensuing years he played for Marion, Toledo, Rock Island, and New York. He also played professional baseball from 1913 to 1919. In 1963 he was made a charter member of the Pro Football Hall of Fame. In 1982 the International Olympic Committee voted to restore the medals it had rescinded nearly 70 years before.

Thorvaldsen, Bertel [tohr'-vahl-sen] Bertel Thorvaldsen, b. Copenhagen, Nov. 19, 1770, d. Mar. 24, 1844, was one of Denmark's most famous sculptors and a leading figure in European NEOCLASSICISM.

The sculptural precision and clarity of Bertel Thorvaldsen's Hebe *(1806) is characteristic of his neoclassical style, derived from Greek and Roman artistic traditions. The 19th-century Danish sculptor worked in Rome for most of his life and used themes from classical antiquity as the principal subjects for his sculptures. The Thorvaldsen Museum (1839–48), which houses his tomb and much of his artwork, is in Copenhagen. (National Museet, Copenhagen.)*

Thorvaldsen executed important commissions throughout Europe, including his monumental *Triumphal Entry of Alexander the Great into Babylon* (1812; Quirinale Palace, Rome), which celebrated a visit to Rome by Napoleon I. After the death (1822) of Antonio Canova, Thorvaldsen became the principal spokesman for neoclassical art and Europe's most influential sculptor. Although he is still admired for his modeling and draftsmanship, his highly finished works are generally regarded by modern critics as cold and lifeless when compared with the more baroque forms of Canova or of John Flaxman. Among his most successful works are carved reliefs such as *Cupid Received by Anacreon* (1823; Thorvaldsen Museum, Copenhagen), which exemplifies the clarity, intensity, and simplicity of his interpretation of classical sources.

Thoth [thahth] Thoth was the Greek name for the Egyptian deity Djhowtey, god of learning, wisdom, and magic. In late Egyptian mythology he was the creator and orderer of the universe and the inventor of writing, arithmetic, and astronomy. Thoth was depicted as an ibis-headed man carrying a pen and an ink holder or as a dog-headed baboon. In the Hellenistic period he was identified with the Greek god Hermes and in later European lore with Hermes Trismegistus, patron of magicians.

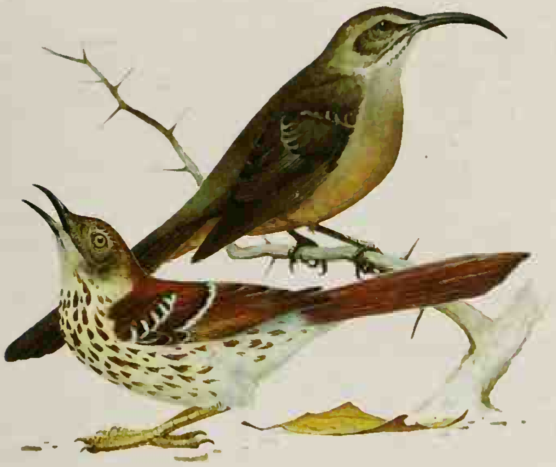
Thousand Islands The Thousand Islands are more than 1,500 densely wooded islands in the St. Lawrence River reaching from Prince Edward Point on Lake Ontario downstream for 130 km (80 mi) to Brockville, Ontario. Several are included in Canada's St. Lawrence Islands National Park, and others are part of New York State.

Thousand and One Nights see Arabian Nights

Thrace [thrays] Thrace is a historic region in the southeastern Balkans, corresponding to the northeastern Greek province of Thrace (Thráki), European Turkey, and southern Bulgaria. The region is bounded by the Black Sea in the east and the Aegean and Sea of Marmara in the south. To the ancient Greeks Thrace extended as far north as the Danube and as far west as the Vardar River. The Roman province of Thrace, however, bounded by the Balkan Mountains in the north and the Nestos River in the west, is the area to which the name *Thrace* is now applied. The terrain is mountainous, but the fertile Thracian plain or Maritsa River valley permits agriculture. Edirne, Istanbul, and Sofia are the principal cities.

Thrace was originally settled by the Thracians. The Greeks began colonizing the region's coasts in the 7th century BC. Byzantium, site of Istanbul, was the most important Greek colony. Thrace was dominated in turn by the Persians, Greeks, and Romans. In AD 46, Emperor Claudius reduced Thrace to a Roman province. From the 3d century AD, Roman, and later Byzantine, control was challenged by repeated Germanic and Slavic invasions. A Bulgarian state was established in the 7th century and, apart from one period of eclipse (1081–1186), dominated the area until the Ottoman Turks overran Thrace between 1361 and 1453. As the Ottoman Empire disintegrated, Thrace was divided, fought over, and redivided among the successor states, Bulgaria, Greece, and Turkey. The present-day political boundaries were created by 1923.

thrasher Thrashers are medium-sized songbirds found in North and Central America. About 17 species, related to catbirds and mockingbirds, are classified in the mimic thrush family, Mimidae. Thrashers range from 20 to 30 cm (8 to 12 in) in length, are slim and long-tailed, and typically have long, more-or-less decurved bills. Most are brown or gray above and spotted or streaked below. The brown thrasher, *Toxostoma rufum*, of the eastern United States, breeds as far north as southern Canada. Reddish brown above, white and heavily striped below, it has two white wing bars. It feeds on insects and fruit and, like other thrashers, vocalizes a variety of sounds as well



The brown thrasher (left) *is the only thrasher found east of the Rockies. The California thrasher has short wings and often runs on the ground instead of flying. Both feed on the ground, using their curved bills to search for food.*

as a lengthy song. Both parents typically incubate the four pale green, spotted eggs and care for the chicks.

thread Thread is a tightly twisted strand of fiber that is spun from silk, cotton, wool, or SYNTHETIC FIBERS. Thread is generally more tightly twisted, and of thinner diameter, than yarn (see SPINNING). Cotton thread was first commercially manufactured in Paisley, Scotland, in 1806, when the Napoleonic blockade of Britain cut off the supply of silk thread. Cotton quickly surpassed silk in popularity because it was strong and low in price. To make thread, cotton fibers are cleaned, combed, and rolled into firm coils. The coils are stretched on a drawing frame and flattened by heavy rollers. These fiber ribbons are then folded, pressed, and drawn out on doubling frames. Finished thread is dyed or bleached and wound on spools or bobbins. Cotton thread is often mercerized, or immersed in a caustic soda solution, which increases strength and luster and gives the thread a greater affinity for dye.

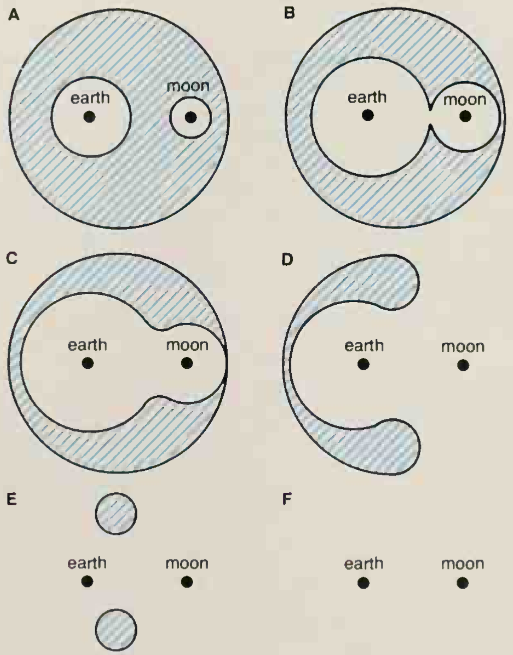
Thread is numbered according to thickness, the lower numbers representing the thicker threads. Buttonhole twist, a strong lustrous silk thread, is three times the diameter of fine sewing silk and is used for handworked buttonholes. Synthetic thread withstands high-speed machine sewing and offers great resistance to seam failure and abrasion.

three-body problem A classic, unsolved problem is to describe and predict the motions of three objects (or "point masses") whose movement is subject only to their mutual gravitational attractions. The situation is approximated in many instances in nature. For example, a number of triple-star systems have been observed; a good approximation for the motion of an asteroid is found by considering only the Sun, Jupiter, and the asteroid; and to specify the motion of the Moon, the primary problem to be solved is that in which only the Earth, Moon, and Sun are taken into account. The laws governing the motion of the three bodies are Newton's laws of motion and the law of gravitation. The corresponding two-body problem was completely solved by Isaac Newton, but the three-body problem has been solved for only a few special cases. The most famous of these were discovered by Leonhard EULER and Joseph Louis de LAGRANGE.

Colinear Case. Euler showed (1767) that three bodies can lie permanently on a straight line that will usually rotate in space in a plane. The colinear solutions are unstable because a small disturbance will lead to a large departure from colinearity. For a system consisting of the Earth, Moon, and a space vehicle, the colinear points, especially the one between the Earth and the Moon, are considered as possible "parking" points for the vehicle because only a small amount of guidance would be needed to keep it there.

Triangular Case. Lagrange showed (1772) that three bodies can lie at the apexes of an equilateral triangle, which in general rotates in its plane and pulsates. If one

A massless body (such as a space vehicle) of sufficiently low energy is confined permanently within the so-called Hill regions, named for the American mathematician George William Hill. As the energy of the body increases (from Figures A to F), the Hill regions (white) *expand and the forbidden regions* (shaded) *contract. With sufficient energy a space vehicle can escape the Earth and approach the Moon, and with still more energy it can escape from the Earth-Moon system.*



of the bodies is sufficiently massive compared with the other two, then the triangular configuration is apparently stable, but this theory has not been rigorously proved. Two groups of asteroids in the solar system, called the Trojans, are so located that, on the average, they, the Sun, and Jupiter form equilateral triangles.

General Case. Almost any particular orbit can be followed by numerical calculation, but it can be followed only for a limited time because of the errors that inevitably accumulate in such a computation. Also, approximate formulas can be found for orbits, but these are useful only over a limited period. Instead of asking for detailed quantitative information, the following qualitative questions might be asked: Can motion such as that presently followed by the system Earth, Moon, and Sun remain similar for all time? Can two bodies capture a third to form a permanently bound triple system? What can be said about the permanence or stability of a triple-star system? In general, such questions cannot be answered, but scientists do know that capture is at least extremely unlikely and that if three bodies are put together in a random way, one will almost certainly escape.

The Restricted Problem of Three Bodies. A simplified version of the problem is the restricted problem of three bodies. In this case, one of the bodies is assumed to be "massless"—in other words, to have mass so insignificant as not to affect the motion of the other two, which move around each other in circular orbits, while the massless body (which is affected, of course, by the other two) moves in the common orbital plane. The motion of a space vehicle in the Earth-Moon system is an approximation to this problem. This is one of the most famous problems in mathematics and remains unsolved.

Three Musketeers, The A historical novel by Alexandre DUMAS père, *The Three Musketeers* (1844) is set during the reign of LOUIS XIII (1610–43) and based on actual events. Three musketeers, loyal servants of the king, are joined by the dashing D'Artagnan; the four together take on Louis's enemies, in particular the soldiers of Cardinal Richelieu. Influenced by Sir Walter Scott, Dumas's narrative is dramatic and abounds in local color. It was so successful that Dumas wrote two sequels: *Twenty Years After* (1845; Eng. trans., 1846) and *The Vicomte of Bragelonne* (1850; Eng. trans., 1857).

Threepenny Opera, The *The Threepenny Opera* is a popular play by Bertolt BRECHT, with music by Kurt WEILL, first produced in 1928. An adaptation of John Gay's *The Beggar's Opera* (1728), it is an anticapitalistic satire that caustically portrays European culture between the two world wars. The robber, Macheath, marries Polly Peachum; her father, furious at the marriage, has Macheath arrested in a brothel with his favorite, Jenny. In prison, Macheath captures the heart of Lucy, the police chief's daughter, who engineers his escape. Rearrested and about to be hanged, Macheath is saved by a royal pardon.

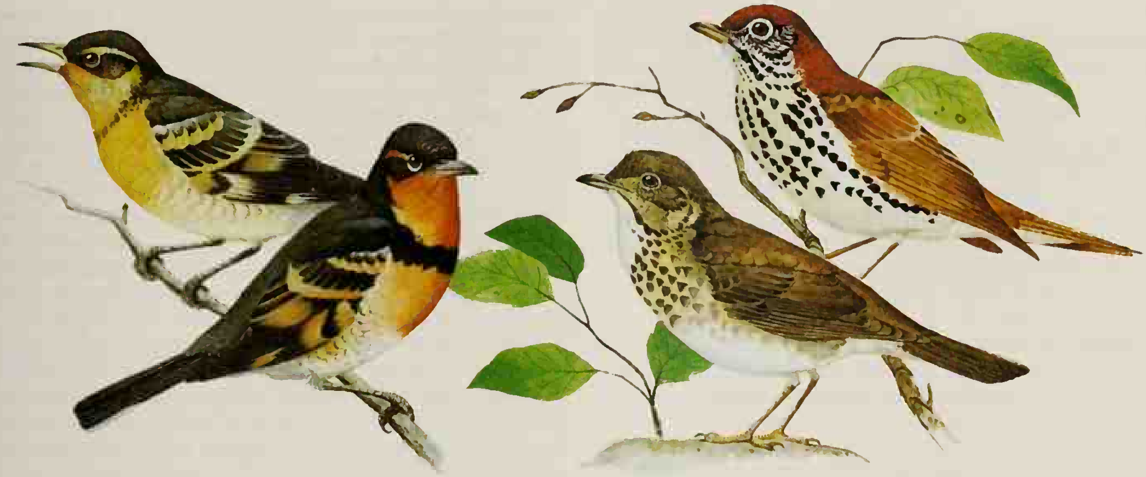
thrips Numbering about 4,000 species worldwide, thrips are common insects comprising the order Thysanoptera. Rarely longer than 3 mm (1/8 in), thrips can be serious pests of cultivated plants. Feeding on flowers, leaves, and even twigs with their conical, sucking mouthparts, thrips cause severe injury to plant epidermal cells. Prolific breeders, thrips can spawn several generations each year. Males are rare or unknown in some species, and parthenogenesis—the development of new individuals from unfertilized eggs—is common. Generally black or brownish, most species have two pairs of narrow wings.

thrombophlebitis see PHLEBITIS

thrombosis [thrahm-boh'-sis] Thrombosis is the formation of a blood clot (thrombus) in a blood vessel. It can occur when a blood vessel is injured by infection or trauma. If the injury is caused by bacteria, they may eventually disintegrate the clot, causing infectious particles to be carried through the bloodstream to establish secondary infections (metastases) at other sites. Alternatively, the entire clot can break loose, especially in the absence of infection, and be carried through the circulatory system until it reaches a blood vessel too narrow to pass. There it lodges and instantly blocks circulation, a condition called *embolism*. Tissues normally supplied by the obstructed vessel disintegrate and die unless their needs can be met by other nearby blood vessels called *collaterals*. The clinical consequences of an embolism depend on where it occurs. If it occurs in the brain, it can cause a stroke. If it occurs in a coronary artery, it can cause a heart attack.

Through the Looking-Glass A fantasy written for older children, Lewis CARROLL's *Through the Looking-Glass, and What Alice Found There* (1872) is a sequel to ALICE'S ADVENTURES IN WONDERLAND (1865). The book recounts a dream in which Alice moves across the landscape of a chessboard until she is crowned queen. The plot is elaborated as a game of chess, and in characters such as Humpty Dumpty and poems such as "Jabberwocky" Carroll has sophisticated fun with the conventions of logic and language. Even more than its predecessor, the book is permeated by a sense of the sadness of growing up, especially in the character of the White Knight.

thrush (bird) Thrushes, family Turdidae, comprise more than 300 species of SONGBIRDS, including some of the world's best-known birds: the American robin, *Turdus migratorius*; the European blackbird, *T. merula*; bluebirds, genus *Sialia*; and the nightingale, *Luscinia megarhynchos*. A number of other birds not in the thrush family also have the word *thrush* as part of their common name. Thrushes are found throughout the world, except in New Zealand and Antarctica, but are most numerous in the Old World. Many species are migratory.



The song of the varied thrush (female and male, left) *is a series of long notes on different pitches. Songs of the Swainson's thrush* (center) *and the wood thrush* (right) *have patterns of flutelike phrases.*

Thrushes are from 10 to 33 cm (4 to 13 in) long and have stout legs—with a characteristic scale arrangement called a booted tarsus—and stout feet. Many of the adults are brownish and often spotted; the young are at least partially spotted. The birds feed mainly on insects, but they also eat fruit. The female alone usually builds an open, cup-shaped nest of grass, leaves, and moss and incubates the two to six pale-colored, often spotted eggs.

The wood thrush, *Hylocichla mustelina*, is a familiar North American thrush. It has cinnamon upper parts and a spotted white breast and sides and is known for its flutelike song.

thrush (infection) see CANDIDIASIS

Thucydides [thoo-sid'-i-deez] Thucydides, *c.*460–*c.*400 BC, the Athenian historian of the PELOPONNESIAN WAR, is considered by many to be the greatest of the ancient Greek historians. His work had a profound influence on the development of historical writing.

Thucydides began writing his *History of the Peloponnesian War* in 431 when the great war broke out. He believed that his account of the war would possess permanent value because such significant conflicts were bound to occur in future epochs "so long as human nature remained the same." The speeches he inserted into his history, brilliantly conceived and written, probe deeply into human motivation and explain the policy of states in terms of human psychology.

Thucydides, the first Greek to write contemporary history, was deeply indebted to HERODOTUS for his conception of the fundamental importance of historical writing. Unlike Herodotus, however, who considered it his duty to repeat what people said without necessarily subscribing to it, Thucydides made every effort to authenticate the facts he reported, and he shows unusual sophistication in his awareness of the way that witnesses often misremember what they have seen.

Generally, his *History* is remarkable for its objectivity, although his treatment of Sparta and Athens shows that he greatly admired the qualities attributed to the Athenians—inventiveness, daring, and aggressiveness. The *History* is incomplete, ending abruptly with Thucydides' narrative of the events of 411 BC.

Thucydides, a 5th-century-BC Greek historian and member of the Athenian aristocracy, is remembered for his History of the Peloponnesian War, *a record of the decline of Athenian power. Thucydides' importance as a historian lies in his emphasis on individual action rather than fate in controlling the course of events.*

Thugs [thuhgz] The Thugs (from Sanskrit, "to conceal") were organized gangs of murderers who for more than 600 years wandered India robbing and killing wayfarers by ritual methods (strangling with scarves) and with sacrificial rites accompanying the burial. Devoted to KALI, the terrible form of Shiva's consort, the Thugs had their own jargon and signs of recognition and functioned as a subcaste within the Indian social structure. In the 1830s the British administration, in cooperation with some of the princely states, rounded up most of the Thugs.

thulium [thoo'-lee-uhm] Thulium is a lustrous metallic element of the rare-earth LATHANIDE SERIES of the PERIODIC TABLE. Its symbol is Tm, its atomic number is 69, its atomic weight is 168.934, and its valence is 3. It was discovered by the Swedish chemist Per Teodor Cleve in 1879. The synthetic isotope ^{170}Tm is radioactive and used as a source of gamma rays in portable X-ray machines.

Thunder Bay Thunder Bay, one of Canada's largest ports, was formed in 1970 by the merger of Fort William and Port Arthur. Located in west central Ontario on Lake Superior's Thunder Bay, it has a population of 112,272 (1986). The city is a major grain shipping center; other economic activities include mining, paper and pulp milling, food-processing, lumbering, and shipbuilding.

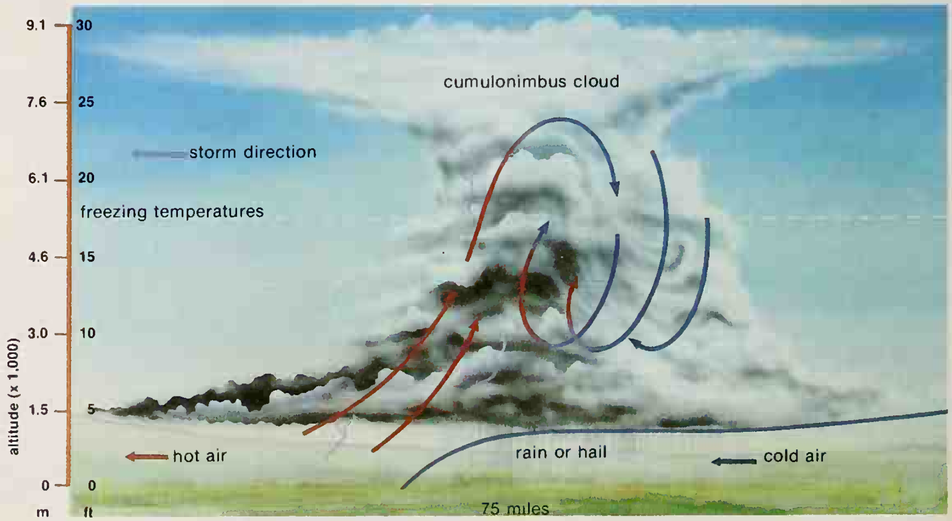
The inhabitants of the area when the first Europeans came were Ojibwa Indians. Probably first settled by the French in the 1670s, the site was permanently settled in the early 19th century when the North West Company built the fur-trading port of Fort William. Port Arthur developed as a silver-mining city after the 1870s. In the 1880s the Canadian Pacific Railway boosted the area's growth, and in 1906 the two cities merged their harbors.

thunderstorm Heating of the Earth's land surface often causes thermals, or parcels of warm air, to rise to the level of condensation. If the thermals contain sufficient moisture and the atmosphere is conditionally unstable, towering cumulus clouds may form. Under suitable conditions the cumulus towers may merge to form cumulonimbus clouds, which have the distinctive feature of an anvil-shaped top. Cumulonimbus clouds in turn produce thunderstorms, which are local storms accompanied always by LIGHTNING and thunder, often by strong gusts of wind and heavy rainfall (see PRECIPITATION, weather), and occasionally by TORNADOES and hail.

Thunderstorms play an important role in the hydrologic cycle and general circulation by vertically transporting a large part of the heat and water vapor that enters the atmosphere from the Earth's surface in response to solar heating. Thunderstorms produce a large fraction of the annual rainfall in many areas of the world, especially the semiarid and tropical equatorial regions. In most areas of the world, especially those regions in the United States, Canada, and Ukraine where corn and wheat are the major crops, rainfall during the peak growing season is supplied by thunderstorms. Thunderstorms are also the engines of tropical disturbances that bring a large fraction of the annual rainfall to tropical coastal regions.

Formation and Circulation

During the cumulus stage, the growing cloud is characterized by the initial formation of small precipitation elements and the presence of generally active updrafts throughout its vertical extent. Updraft velocities may exceed 10 m/sec (33 ft/sec) in the interior of the cloud. In the mature stage the cloud has expanded laterally and grown to greater heights in the atmosphere. A strong updraft over a broad area exists in the cloud's upper levels. In a less intense thunderstorm a downdraft originating at



Thunderstorms occur when a rapidly moving mass of cold air overtakes and lifts a large mass of warm, humid air. The result is a strong updraft of air and the formation of a huge cumulonimbus cloud. Raindrops form in the warm air at low altitudes, whereas ice crystals and snow form in the upper cold regions of the cloud. Subsequent strong downdrafts produce the heavy rain or hail.

heights of 3 to 5 km (2 to 3 mi) above the cloud base often pinches off the updraft air at low levels, leading to the eventual demise of the cloud. New clouds frequently form along an advancing air mass that is chilled by the evaporation of rain and that emanates from the downdraft spreading laterally beneath the cloud. Thunderstorms often contain precipitation in the form of raindrops, graupel, and small hail in the interior of the cloud and snowflakes in the outflow levels and the cirrus anvil. Moderate to heavy rainfall occurs over broad regions below the cloud base. Eventually the updraft weakens and a downdraft spreads throughout the cloud, weakening the rainfall and dissipating the cloud.

Destructive Potential

A small fraction of the total number of thunderstorms develop into exceptionally large and intense severe local storms that produce violent windstorms, tornadoes, large hailstones, heavy rainfall, and intense lightning. Severe local storms typically form in air masses that exhibit high conditional instability, have a well-organized source of low-level moisture convergence, and exhibit substantial shear, or change in speed and direction of the horizontal wind per unit of height, through a deep layer of the atmosphere.

Thunderstorms are notorious for their destructive potential. Thunderstorm-associated lightning causes 100 to 200 deaths and several hundred million dollars worth of property damage and ignites approximately 10,000 forest fires each year in the United States alone. Hail annually causes several hundred million dollars worth of crop loss in the United States. Downbursts, the outflow from intense downdrafts, can produce maximum surface wind speeds in excess of 80 m/sec (180 mph), causing considerable structural damage and creating a potential hazard for aircraft landing or departing from airports. Flash floods, generally caused by relatively stationary and persistent thunderstorms forming over watersheds feeding deep valleys and canyons, are rapidly becoming one of the highest-ranking forms of storm-related killers because of the continued expansion of urban areas into flood-prone areas.

Thurber, James [thur'-bur] Highly regarded as an American humorist, James Grover Thurber, b. Columbus, Ohio, Dec. 8, 1894, d. Nov. 2, 1961, is remembered for his *New Yorker* essays and cartoons, for such short stories as "The Catbird Seat" and "The Secret Life of Walter Mitty," for children's books including *The Thirteen Clocks* (1950), and, as coauthor with Elliot Nugent, for the witty Broadway play *The Male Animal* (1940). Thurber portrayed the modern world in all its confusions and frustrations, most successfully in two self-illustrated books—*Fables for Our Time* (1940) and *Further Fables for Our Time* (1956). About animals who talk and act like Thurber's fellow Americans, the fables present such morals as "It is better to have the ring of freedom in your ears than in your nose."

Thuringia [thur-in'-jee-uh] Thuringia (German: Thüringen) is a state in east central Germany (1990 est. pop., 2,684,000). Important cities include Gera, Gotha, Jena, and Weimar; Erfurt is the capital. The Thuringian Basin, where most of the inhabitants live, contains most of the arable land. Thuringia has numerous rivers, many of them harnessed for hydroelectric power.

The region's name is derived from the Thuringians, a Germanic tribe that arrived after AD 350. Thuringia was under Frankish rule from about 634 to 814. The house of Wettin controlled the region from 1265 to the 15th century. Thuringia was successively a part of the duchy—and then kingdom—of Saxony (1485–1918), a state under the Weimar Republic (1919–34), a part of Saxony (1934–45), and a part of East Germany (1945–90).

Thurmond, Strom [thur'-muhnd, strahm] James Strom Thurmond, b. Edgeville, S.C., Dec. 5, 1902, has served as U.S. senator from South Carolina since 1954. In 1946, Thurmond was elected governor of South Carolina, and in 1948 he ran for president as the candidate of the Southern, anti-integration States' Rights Democrats, who opposed President Harry S. Truman's liberal civil rights policies. Thurmond carried four states. A Republican from 1964, he was chairman of the Senate Judiciary Committee from 1981 to 1987.

Thurstone, L. L. [thur'-stuhn] Louis Leon Thurstone, b. Chicago, May 29, 1887, d. Sept. 29, 1955, was a pioneer in the field of psychological measurement. Thurstone's contributions to psychological test theory provide the foundation for today's aptitude and achievement tests and for modern methods of assessing attitudes and opinions. He is best known for having developed multiple-factor analysis, a procedure widely adopted in the social sciences for analyzing relations among sets of variables. Thurstone was a dedicated teacher, and many of his students have become distinguished psychologists.

James Thurber amused readers with his sketches and fables beginning with his first work, My Life and Hard Times, *in 1933. Thurber's short stories often portray human beings in the modern age as virtually impotent in the face of simple everyday events.*

Thus Spake Zarathustra see NIETZSCHE, FRIEDRICH WILHELM

Thutmose I, King of Egypt [thut'-mohz] Thutmose I, d. *c.*1512 BC, 18th-dynasty king of Egypt (r. *c.*1525–*c.*1512), successor to his father, Amenhotep I, extended his empire southward deeper into Nubia; later, during his Asian campaigns, he reached the Euphrates. He was the first king to be buried in the VALLEY OF THE KINGS at Thebes.

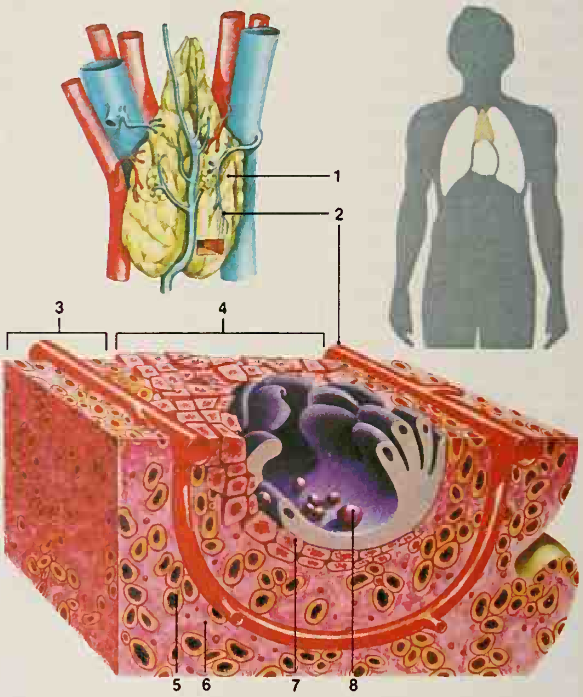
Thutmose II, King of Egypt Thutmose II (r. *c.*1512–*c.*1504 BC) was an Egyptian king of the 18th dynasty. He married his half sister HATSHEPSUT and succeeded his father, Thutmose I. During his reign Thutmose put down rebellions in Nubia and Palestine and continued temple construction at KARNAK.

Thutmose III, King of Egypt Thutmose III, d. 1450 BC, 18th-dynasty ruler of Egypt (*c.*1504–1450 BC), the greatest of ancient Egypt's warrior kings, expanded and consolidated Egyptian control over an empire of unprecedented extent in western Asia and Africa. Thutmose was young when his predecessor and father, Thutmose II, died; he had to serve as junior partner in a co-kingship with his aunt HATSHEPSUT until 1482. Between 1482 and 1462, he personally led many victorious campaigns in Syria, Palestine, and Phoenicia. In a battle on the east bank of the Euphrates he defeated the powerful kingdom of Mitanni, his chief rival for control of the Near East. Meanwhile, his armies in Nubia pushed beyond the Nile's 4th cataract. Thutmose set up an efficient administration in the conquered territories, in which vassal kings and chiefs were forced to pay heavy tribute to Egypt. Much of this tribute Thutmose used to build new temples in gratitude to the Egyptian gods.

thyme [tym] Thyme is the common name for about 300 to 400 species of the genus *Thymus*, family Labiatae, that are native to temperate Eurasia. French thyme (also called German or English thyme), *T. vulgaris*, is a perennial herb whose leaves provide the common thyme of the spice shelf; the oil extracted from the plant is used in perfumes and medicines. Some species and varieties of thyme are scented with such distinct odors as caraway, lemon, or oregano. Wild or creeping thyme, *T. serpyllum*, is a popular rock-garden evergreen.

thymus [thy'-muhs] The thymus is a vascular organ of the lymphatic system situated just behind the breastbone. The human thymus continues to grow for about a year after birth, reaching a weight of about 42 g (1.8 oz); this size is maintained until puberty. After puberty the lymphatic tissue is replaced by fat, but the thymus remains functional throughout life.

The main function of the thymus is to process lymphocytes received from the blood-producing bone marrow and fetal liver. These cells proliferate and differentiate in the thymus into thymic lymphoid cells called T cells, each one programmed for the number of antigens to which it will react. In humans the cellular immune system requires the presence of the thymus at birth; this system allows the body to recognize foreign—that is, "nonself"—tissue and to attack malignant cells, viral infection, fungal infection, and some bacteria (see also IMMUNITY, biology). Little is known of the factors and processes of thymic function. The importance of the thymus to the human immune system, however, is readily demonstrated in some patients with congenital thymic-deficiency states by the restoration of immunological responsiveness after fetal thymus grafts.



The thymus gland (1) *is an organ of the lymphatic system, which protects the body against infection. Located behind the sternum, near the heart and lungs, it is well supplied with blood vessels* (2). *Its two main lobes are each subdivided into numerous lobules; a network of delicate connective tissue holds the lobes and lobules together. Within each lobule are two zones of tissue: an inner zone called the cortex* (3) *and an outer zone called the medulla* (4). *The cortex is composed of lymphocytes* (5), *white blood cells that produce antibodies and attack bacteria; these lymphocytes are packed into a fiber structure called a reticulum* (6). *The medulla has a more cellular reticulum* (7) *and contains thymic corpuscles (Hassall's corpuscles)* (8), *which are concentric clusters of epithelial cells enclosing a core of granular cells. The function of these corpuscles is not yet understood. The thymus is most active during fetal and childhood growth, its main functions appearing to be the production of lymphocytes and the destruction of defective lymphocytes. The thymus may also secrete a hormone that influences the response of lymphocytes to foreign tissue. After puberty the thymus slowly degenerates.*

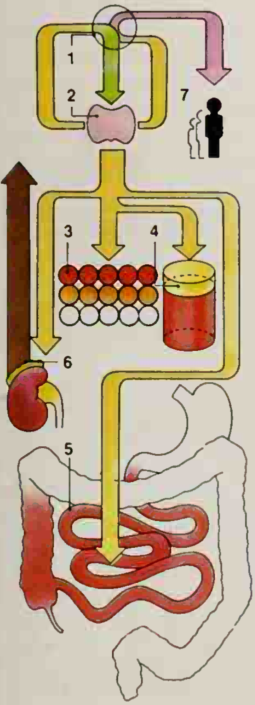
thyratron see ELECTRON TUBE

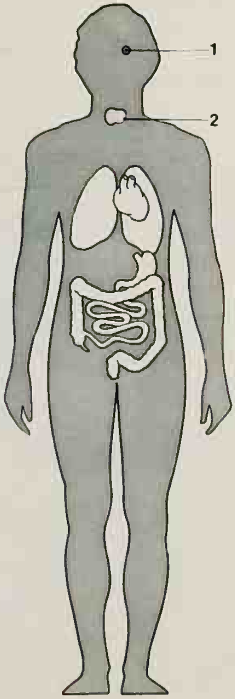
thyroid function test [thy'-royd] A thyroid function test measures the efficiency of thyroxine and triiodothyronine production by the thyroid gland. These two thyroid hormones, which contain iodine, regulate body metabolism. If the hormones are deficient, as in the condition called myxedema, metabolism is slowed down. If they are in excess, as in exophthalmic GOITER, metabolism is accelerated. The oldest method of measuring thyroid function is the determination of the basal metabolic rate, or BMR. The relationship of the BMR to thyroid hormone levels, however, is indirect and inexact. The BMR test has thus been superseded by such tests as the radiation method, which measures the rate at which injected radioactive iodine becomes concentrated in the thyroid gland. This rate is directly related to the rate of thyroid hormone synthesis. Other tests include measurement of the competitive protein-binding of thyroxine, serum thyroxine, the level of thyroid-stimulating hormone (TSH), free thyroxine in blood and urine, and triiodothyronine estimations.

thyroid gland The thyroid, an endocrine gland, synthesizes, stores, and secretes two hormones—thyroxine, or tetraiodothyronine (T_4), and triiodothyronine (T_3)—that are chemically related and important to human growth and metabolism. Located below the larynx (voice box), the thyroid's two lobes occur on either side of the windpipe, connected by an isthmus (band of tissue). The gland is composed of many hollow sacs (follicles) filled with colloid (a gelatin material), which contains thyroglobulin, the storage form of the hormones. Essential to the synthesis of the hormones is inorganic iodide, which diffuses from the blood into the follicle cells. A third hormone, thyrocalcitonin or calcitonin, acts against excessive levels of calcium in the blood and against the effects of parathyroid hormone on bone resorption.

Thyroid hormone secretion is controlled by thyroid-stimulating hormone (TSH), or thyrotropin, from the anterior pituitary. In turn, the resultant increase in the level of thyroid hormones in the blood serves to signal the pituitary to stop releasing the thyrotropin. This homeostatic mechanism keeps the level of thyroid hormones in the circulatory system within a constant range. A lack of thyroid function in infants causes cretinism, whereas a loss or low levels of the thyroid hormones later in life result in hypothyroidism, or myxedema, and possibly GOITER. Overproduction of the hormones, or hyperthyroidism, also may result in goiter.

See also: ENDOCRINE SYSTEM, DISEASES OF THE.





(Left) *The thyroid gland regulates the body's use of energy. When signaled by the pituitary* (1), *the thyroid* (2) *releases hormones into the bloodstream; the hormones are transported to the body's cells* (3) *and stimulate them to burn more fuel. These hormones affect blood cholesterol levels* (4), *intestinal absorption of sugars* (5), *the adrenal medulla* (6), *which influences the brain, and growth hormone* (7).

thyroxine see HORMONE, ANIMAL; THYROID GLAND

Thysanoptera see THRIPS

Thysanura see BRISTLETAIL

Tiahuanaco [tee-ah-wah-nah'-koh] The important pre-Columbian site of Tiahuanaco (also Tiahuanacu), near the eastern margin of Lake Titicaca on the Bolivian altiplano at an altitude of about 4,000 m (13,125 ft), was occupied from about AD 100 to perhaps 1000. Within Tiahuanaco's extensive fine-cut masonry ruins archaeologists have defined six architectural complexes, all of which were probably used primarily for religious ceremonies. The most important structure, the Kalasasaya, is near the center of the site; the so-called Subterranean Temple lies to the east, and the enclosures of Putuni, Laka Kollu, and Q'eri Kala are on the west. Still farther west, near the lake, is a sizable cemetery.

The motifs and art styles of Tiahuanaco heavily influenced large areas of highland Bolivia, southern Peru, northern Chile, and northwest Argentina during the period 500–1000. Little is known of the sociopolitical organization that underlaid this pervasive influence, although Tiahuanaco was probably able to export elements of its religion and may have established important economic links with far-flung areas. Recent evidence suggests that the site may have been much larger than its core zone of elaborate structures and thus have had a sizable resident population.

See also: PRE-COLUMBIAN ART AND ARCHITECTURE.

Tian Shan (Tien Shan) [tee-en shahn] A mountain range located in Central Asia, the Tian Shan (Chinese, "celestial mountains") extend 3,000 km (1,800 mi) from the USSR's Kirghizia northeast through the Xinjiang region of western China to the Mongolian frontier. The Gissar-Alai, Chu-Ili, Karatau, K'a-erh-li-k'o, and Dzhungarian Alatau mountains all belong to the Tian Shan, whose highest point, Pobeda Peak on the Kirghiz–Xinjiang border, reaches 7,444 m (24,406 ft). Principal rivers of the range include the Chu, Ili, Naryn, Sarydzhaz, and Zeravshan. The Kirghiz, UIGHUR, and Chinese who inhabit the mountains maintain an economy based on agriculture and herding. Copper, lead, zinc, mercury, antimony, and tungsten are mined.

Tianjin (Tientsin) [tin-jin] Tianjin, a city in northeastern China in Hebei province, is one of the leading industrial centers of the country. China's third largest city, Tianjin has a population of 5,620,000 (1989 est.). It is located on the Grand Canal about 130 km (80 mi) southeast of Beijing, at the confluence of the five major tributaries of the Hai He near the Bo Hai (gulf) of the Yellow Sea. Tianjin is known for its chemical and textile industries and handicraft products. The city's wide range of manufacturing industries produce iron and steel, machinery, electronics equipment, paper, and processed food. Salt production and fishing are important along the Bo Hai. Tianjin is also one of China's leading ports.

A transport center since the 10th century, Tianjin was opened to urban and commercial development by concessions made to European nations in the 19th century, including the Treaties of Tianjin (1858) signed after China's defeat in the Second OPIUM WAR. It was the capital of Hebei province (1955–67) but is now under the direct administration of the national government. About two-thirds of the city was destroyed or damaged by a 1976 earthquake; there has since been substantial rebuilding.

Tibbett, Lawrence Lawrence Tibbett, operatic and concert baritone, b. Bakersfield, Calif., Nov. 16, 1896, d. July 15, 1960, made his Metropolitan Opera debut as a monk in Mussorgsky's *Boris Godunov.* He spent two years in a succession of small roles before winning sensational success as Ford in Verdi's *Falstaff* on Jan. 2, 1925. He created an impressive list of roles in new operas, notably the title parts in Deems Taylor's *Peter Ibbetson* (1931) and Louis Gruenberg's *Emperor Jones* (1933) and the leading baritone role in Howard Hanson's *Merry Mount* (1934). He was often heard on radio and in recitals and appeared in several films.

Tiber River [ty'-bur] The 406-km-long (252-mi) Tiber River, the second longest in Italy, rises in the Etruscan Apennines, about 65 km (40 mi) east of Florence, and flows south past Perugia to Rome, 26 km (16 mi) from its mouth on the Tyrrhenian Sea. Navigable only near Rome, the Tiber is not commercially important. In ancient times it served as a boundary between Latin tribes in the south and Etruscans in the north.

Tiberias [ty-bir'-ee-uhs] Tiberias (Teverya in Hebrew), one of the four holy cities of Judaism, is a port on the western shore of the Sea of Galilee in northeastern Israel. It has a population of 29,000 (1982 est.). A commercial and transportation center, Tiberias is a popular resort.

Founded by Herod Antipas in AD *c.*20 and named for the Roman emperor Tiberius, the city became the center of Jewish scholarship in the 2d century. The Mishnah and the Jerusalem Talmud were edited there. In 636 the city was taken by the Arabs, and it was destroyed during the 12th century. Tiberias was reestablished during the 18th century.

Tiberias, Lake see GALILEE, SEA OF

Tiberius, Roman Emperor Tiberius Julius Caesar Augustus, b. Nov. 16, 42 BC, d. Mar. 16, AD 37, was the second emperor (r. AD 14–37) of Rome. He was the son of Tiberius Claudius Nero and LIVIA DRUSILLA, who later married Octavian (see AUGUSTUS). In 12 BC, Tiberius was forced to marry Augustus's daughter, Julia. In the event of Augustus's death he was to act as tutor of Augustus's grandsons by Julia's previous marriage. Tiberius resented his role, and from 6 BC to AD 2 he lived in retirement in Rhodes. After the premature deaths of the grandsons, Augustus adopted (AD 4) Tiberius and recognized him as his successor.

Tiberius was an accomplished general. He quelled revolts in the Danubian provinces (12–9 BC), fought in Germany (9–7 BC, AD 4–6) and elsewhere, and won the allegiance of his soldiers. When Augustus died, Tiberius was already in possession of the chief military command; after a show of reluctance, he let the Senate proclaim him emperor. A scheming and suspicious ruler, Tiberius instituted a reign of terror, especially after AD 23, when Sejanus, prefect of the Praetorian guard, became his chief advisor. Numerous senators, and also members of the family of his nephew GERMANICUS CAESAR, were accused of treason and executed; in 31, Sejanus met the same fate. Tiberius ruled from AD 26 until his death in seclusion on Capri; he was succeeded by Caligula.

Tibesti Massif [tee-bes'-tee] The Tibesti Massif is a mountainous region in the central Sahara. Located mainly in northern Chad but extending into southern Libya, it has a total east-west length of about 485 km (300 mi) and a maximum north-south width of about 280 km (175 mi). The highest peak, the extinct volcano Emi Koussi, rises to 3,415 m (11,204 ft). Of volcanic origin, these extremely rugged mountains arose when the Sahara's climate was more humid. The sandstone-covered rocks have been shaped by water and wind erosion into complicated shapes. Vegetation is sparse, although crops are grown in oases. Seminomadic tribes raise camels, sheep, and goats. The first European to explore (*c.*1870) the range was Gustav Nachtigal.

Tibet (Xizang) [ti-bet'] Tibet, since 1965 the Tibetan Autonomous Region of the People's Republic of China, forms the southwestern part of China. Tibet has an area of 1,221,700 km^2 (471,700 mi^2) and has about 1,930,000 inhabitants (1983 est.). The awesome Himalayas form Tibet's southern boundaries with India, Nepal, Bhutan, Burma, and Pakistan.

Land and People. Much of Tibet consists of the largest and highest plateau on Earth (average elevation: 4,600 m/15,000 ft). The plateau is ringed by mountains, including the KUNLUN MOUNTAINS in the north. In the south the HIMALAYAS contain the world's highest peaks, including Mount EVEREST (8,848 m/29,028 ft), and are the source of the great rivers of east and south Asia, including the HWANG HE and INDUS. Tibet's climate varies little with the seasons. Lhasa's daily temperature ranges from a maximum of 7° C (45° F) to a minimum of –8° C (18° F). Because the monsoons are blocked by the mountains, only 255 mm (10 in) of rain falls annually.

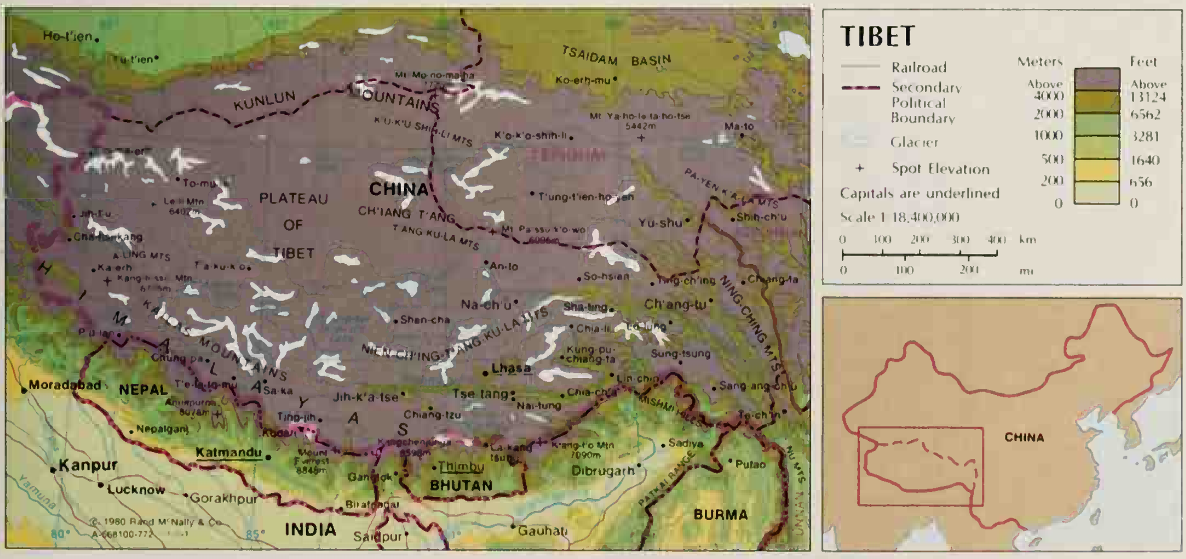
Cultivable land is limited to valleys, mainly in the east and southeast, where the plateau dips below 3,650 m (12,000 ft) and where most of Tibet's inhabitants live. The principal cities and towns are LHASA, the capital; Jih-k'a-tse (Zigazê); Chiang-tzu (Gyangzê); and Ch'ang-tu (Qamdo). The main crop is barley, cultivated with the aid of the native yak, or the dzo, a cross between a cow and a yak. Butter made from the milk of these animals, mixed with ground barley in tea, makes tsampa, the staple of the Tibetan diet.

History. The plateau's harsh environment, its physical isolation, a strong isolationist policy by its leaders, and the independence of its people kept Tibet free of direct foreign control for much of its history. The Tibetans developed the form of Buddhism called Lamaism (see TIBETAN BUDDHISM). The monks (lamas) who headed the many great monasteries and Buddhist sects held political power and owned the land. The DALAI LAMA, the temporal and spiritual leader, was believed to be the reincarnation of the ancestor of all Tibetans. The Panchen Lama was the secondary spiritual leader.

By the 7th century the independent kingdom of Tibet was flourishing. In 1207, Tibet paid tribute to Genghis Khan, the Mongol emperor. From 1279 to 1368, Tibet was under the control of the YUAN (Mongol) dynasty of China, but subsequently regained its independence. Tibet came under the nominal protection of the Chinese Qing dynasty (established 1644), although for the most part the country retained control over internal affairs. In 1903 the British colonel Francis YOUNGHUSBAND led a military expedition to Lhasa to establish trading posts. Treaties (1906, 1907) between China and Great Britain recognized China's sovereignty over Tibet.

With the downfall (1911) of the Qing, Tibet declared its independence, maintained until 1950. In that year Chinese forces invaded to gain control of what was considered a strategic border area, and in 1951 a defeated Tibet signed a treaty making it part of China. In 1959 resentment of Chinese domination erupted into an uprising, violently crushed by Chinese forces. The Dalai Lama and about 100,000 of his followers escaped to India, and the Panchen Lama (d. 1989) was installed (1959–64) as nominal head of government. In 1965, Tibet officially became an autonomous region of China.

After 1959 the Chinese abolished serfdom and built roads to improve access to Lhasa. Particularly during the Cultural Revolution (1966–69), they collectivized agriculture and tried forcibly to assimilate the Tibetans. Religious worship was banned, Chinese was declared the official language, and almost all monasteries and other



religious monuments were destroyed. In 1980 the Chinese government tacitly admitted that its policies had caused economic hardship and failed to eradicate the Tibetan identity. Holy sites were reopened, and Tibetan language and culture were no longer rigidly suppressed. Per capita income remained low, however, and Han Chinese settlement continued. After 17 months of renewed Tibetan protests against Chinese rule, martial law was imposed in Lhasa from March 1989 to May 1990.

Tibetan art see LAMAIST ART AND ARCHITECTURE

Tibetan Buddhism Tibetan Buddhism, also called Lamaism, is a distinctive form of BUDDHISM that arose (7th century) in Tibet and later spread throughout the Himalayan region, including neighboring Bhutan, Nepal, and Sikkim. The history of Tibetan Buddhism can be divided into three periods. During the 7th–9th century AD Buddhism was first introduced from India and was slowly accepted under Buddhist kings in the face of opposition by adherents of the indigenous shamanistic religion of Tibet, Bon. During the 9th century, however, King gLang Dar Ma persecuted the new faith and effectively eclipsed it for some time.

The second period began with the reintroduction of Buddhism from India and its successive reform in the 11th century. Powerful ecclesiastical organizations were established and soon began to rule the countryside in alliance with clans of nobles or the distant Mongol rulers. During this period the Tibetan Buddhist canon (notable for its accurate translations of now-lost Sanskrit texts and its helpful commentaries) was compiled, and some of the sects that have persisted to the present were formed.

The third period began with the great reformer Tsong-kha-pa (1357–1419), who founded the dGe-lugs-pa sect—the so-called Yellow Hats—to which the line of the DALAI LAMAS belongs. Each of these lamas was thought to be the reincarnation of his predecessor (as well as that of the bodhisattva Avalokitesvara) and became, at least nominally, the religious and secular ruler of the country.

Among the characteristic features of Tibetan Buddhism are its ready acceptance of the Buddhist TANTRAS as an integral and culminating part of the Buddhist way; its emphasis on the importance of the master-disciple relationship for both religious scholarship and meditation; its recognition of a huge pantheon of Buddhas, bodhisattvas, saints, demons, and deities; its sectarianism, which resulted less from religious disputes than from the great secular powers of the rival monastic organizations; and, finally, the marked piety of both monastic and lay Tibetan Buddhists, which receives expression in their spinning of prayer wheels, their pilgrimages to and circumambulation of holy sites, prostrations and offerings, recitation of texts, and chanting of MANTRAS, especially the famous invocation to Avalokitesvara, *Om Mani Padme Hum*.

This child is a 17th incarnate lama of the Yellow Hat (dGe-lugs-pa) sect in Himachal Pradesh state, India. In Tibetan Buddhism, lamaist succession is based on direct reincarnation. It is believed that when a lama dies his soul passes into a newly born infant, who is then sought out by the religious community. Through a series of divinations and tasks, the incarnate lama is identified and revered for life.

Tibetan language see SINO-TIBETAN LANGUAGES

Tibetan terrier The shaggy Tibetan terriers—which are not a true terrier breed of dogs—were originally bred in Tibetan monasteries. Closely resembling the Old English sheepdog and the Lhasa apso, the dogs stand 35 to 40 cm (14 to 16 in) high at the shoulder and weigh 8.2 to 13.6 kg (18 to 30 lb). They have fine, profuse double coats, well-feathered tails curled up over their backs, and loose-hanging ears. They come in many colors, either solid or mottled with white.

tic Two forms of a muscular disorder known as tic occur: nervous tic and tic douloureux. Nervous tic is a recurrent, spasmodic, involuntary reaction that is apt to develop in certain muscles during emotional stress and sometimes accompanies psychoneurotic disorders. Repeated shrugging, blinking, and clearing of the throat are examples of nervous tics. Children are prone to the malady but generally outgrow it. Tic douloureux (trigeminal neuralgia), on the other hand, strikes mainly the elderly. It is a reflex contraction of the facial muscles in response to sharp pain affecting the trigeminal nerve, a cranial nerve serving the entire face; the cause of the nerve damage is generally unknown. The condition can be relieved with drugs such as carbamazepine and phenytoin; surgery is considered only as a last resort.

tick Ticks are small-to-microscopic, eight-legged, often brightly colored bloodsucking parasites that feed on reptiles, birds, and mammals, including humans. Together with closely related mites, they make up the order Acarina of the class Arachnida, phylum Arthropoda. Ticks are found worldwide but are most abundant in tropical and subtropical areas. They attach to the hosts by means of specially adapted mouthparts. Two basic kinds exist: hard ticks, family Ixodidae—with mouthparts visible from above

The Rocky Mountain wood tick is a major transmitter of the diseases known in the United States as Rocky Mountain spotted fever and tularemia, or rabbit fever.

and hard scutes covering all or part of the body—and soft ticks, family Argasidae—with leathery bodies and the mouthparts hidden by the back.

In the typical life cycle, the female lays several thousand eggs that hatch into active six-legged larvae. The larvae feed on a host and develop into eight-legged nymphs, which in turn feed and develop into adults. A few tick species stay on one host for the entire cycle, but most have a new host or hosts in some or every developmental stage.

Hard ticks secrete nerve poisons that sometimes cause paralysis or death. Ticks can also harm their hosts by causing excessive blood loss or by transmitting diseases. Among such diseases are Lyme disease, Q fever, relapsing fever, Rocky Mountain spotted fever, tularemia, and some forms of encephalitis and spirochetosis.

Ticonderoga [ty-kahn-dur-oh'-guh] Ticonderoga, a stone fort between Lake Champlain and Lake George in what is now northern New York State, was an object of contention during the French and Indian War of 1754–63 and the American Revolution. The French built it in 1755 as an outpost of Fort Saint Frederic (Crown Point) and named it Carillon. In 1758 the marquis de Montcalm repulsed a British assault led by Maj. Gen. James Abercrombie in one of the bloodiest battles of the colonial wars. Jeffrey Amherst succeeded in taking it from the French the following year. At the beginning of the Revolutionary War, Ethan Allen and his Green Mountain Boys seized (May 1775) Ticonderoga from the British. Gen. John Burgoyne recaptured it in 1777, but the British abandoned it later in the year. Restored in the early 20th century, it stands today as a historic monument.

tidal bore A tidal bore consists of a tide-generated wave that travels up some rivers about two or three times as fast as the incoming tide. It is formed on those rivers where the mass and momentum of the incoming tide are concentrated into a narrow front by the gradual narrowing of the river channel, by a rise in the river bed, or by both. A tidal bore is highest near the river banks. The largest tidal bore occurs on the Jian Tang Jiang River in China (7.5 m/24.6 ft). Large bores also occur on the Amazon River and in Canada's Bay of Fundy.

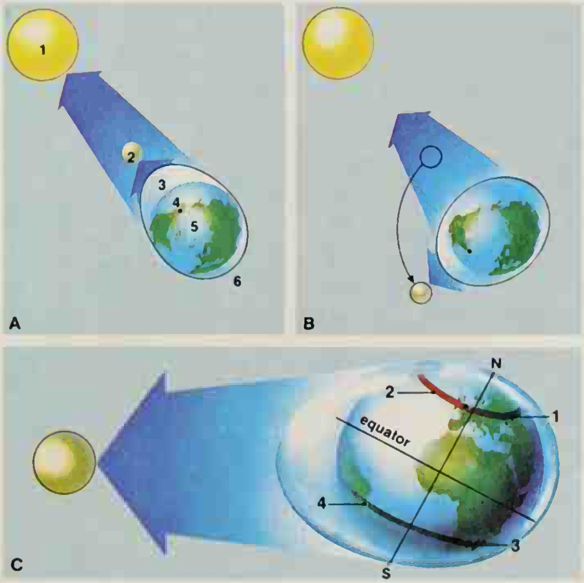
tidal energy At more than 100 coastal locations around the world the tides rise and fall far enough within an estuary or a partially enclosed basin to make the generation of electricity by tidal force economically feasible. Two tidal-energy plants are currently in use: a 240-MW (1 megawatt = 1,000 kilowatts) facility at the mouth of the Rance River, near Normandy, France, and a 400-kW experimental generator at Kislaya Guba, on the White Sea, north of Murmansk, USSR. A 1,500-kW plant is under construction at Mezen, also in the USSR.

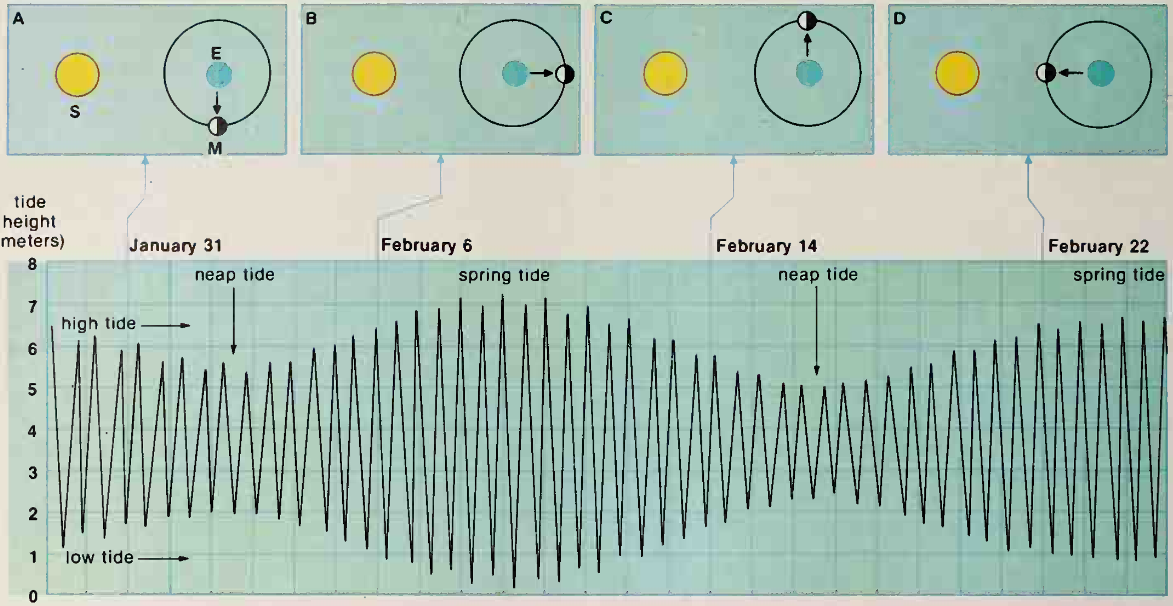
Tidal energy is harnessed by building a barrier across the mouth of an estuary or inlet and by installing turbines in the barrier that are turned by the inflow and outflow of water (see hydroelectric power). At the Rance River plant, where the maximum tidal range is 13.5 m (44 ft), 24 10-MW turbine-generators are in place; the turbines have blades of adjustable pitch to handle varying flow speeds and are reversible so that power can be produced during both the rise and fall of the tides. Tidal-power plants are best used as a contributing element in a utility grid, because the level of power available from them fluctuates.

The world potential of electricity production from the tides may be as high as 60 million kW, an amount equal to 5% of the world's present generating capacity, with a potential of more than 500 billion kW h per year, or greater than 7% of annual world demand.

tide Tides are the periodic rise and fall of the sea surface, occurring once or twice a day. They are to be distin-

Two ocean tides occur on Earth every 24 hr 50 min. (A) During spring tides, a large tidal bulge (3) is produced on Earth (5) by the combined effects of the Sun (1) and the Moon (2). A smaller and opposite tidal bulge (6) is caused simultaneously by centrifugal forces resulting from the Earth's rotation about the common center of gravity (4) of the Earth-Moon system. (B) Smaller neap tides occur when the Sun and Moon partially neutralize each other's effects. (C) Because the axis of the tidal bulges is inclined to the Earth's equator, any particular location on the Earth's surface will experience different tidal heights (1, 2 and 3, 4) during each daily rotation.





When the Sun (S), *Moon* (M), *and Earth* (E) *are in line at full moon* (B) *and at new moon* (D), *the gravitational forces of the Sun and the Moon combine to give spring tides, or higher tides than normal. When the Sun and Moon are at right angles to each other with respect to the Earth at first quarter* (A) *and at last quarter* (C), *the Moon's tidal forces are partially canceled by the Sun's tidal forces, and the resulting neap tides are lower than usual. A graph of tide heights versus time reveals a 2-day lag of the tides behind the Moon's phases.*

guished from tidal surges, which are fluctuations of sea level caused by persistent winds and changes in barometric pressure. Tides may be regarded as surface waves of very long wavelength, whose motions are driven by the gravitational attraction of the Sun and Moon and by the Earth's rotation (see WATER WAVE). Their periods are therefore determined by the periods of these same astronomical forces.

Although it appears that the Moon simply circles the Earth, actually both the Earth and the Moon revolve around a common center of mass located between their centers. A particle of water on the Earth's surface is thus subjected, in addition to the Earth's own gravitational pull, to the gravitational attraction of the Moon and the centrifugal force due to the rotation of the Earth-Moon system. For the system as a whole the latter two forces are in balance. The centrifugal force is the same for all points on the Earth's surface. The Moon's gravitational pull, however, is stronger for those points on the side of the Earth nearer the Moon and weaker for points on the side farther from the Moon. Therefore the gravitational attraction and the centrifugal force are out of balance everywhere on the Earth's surface; the difference between them is the tide-producing force, which has a component parallel to the surface and thus produces tidal currents that cause sea level to rise and fall periodically. The Moon's gravitation pulls the water into a bulge on the side of the Earth under the Moon, and the centrifugal force produces a similar bulge on the opposite side of the Earth.

The gravitational pull of the Sun produces tides in exactly the same way; because the Sun and Earth are much farther apart, however, the tidal forces due to the Sun are only 46 percent of those due to the Moon.

The maximum tides, called spring tides, occur when the Sun, Moon, and Earth all lie approximately in a straight line, so that the tidal forces of the Sun and Moon reinforce each other. Minimum tides, called neap tides, occur when the Sun and Moon are about 90° apart as viewed from the Earth, so that their gravitational attractions partially cancel each other. The levels of spring and neap tides are about 20 percent above and below the average tidal limits.

Concept of Equilibrium Tide. A useful concept for examining the response of the ocean to tide-producing forces is that of the equilibrium tide. This is a simplification based on the assumptions that there are no continents to impede the flow of water on the Earth's surface and that the water is at all times in static equilibrium. The equilibrium tide forced by the Moon consists of high-water bulges directly under the Moon and on the opposite side of the Earth and of two low-water troughs in the other quadrants. As the Earth rotates, an observer who remains in one location will see two high waters and two low waters per day (the semidiurnal tide) as the bulges and troughs pass by. The equilibrium tide forced by the Sun is similar but smaller; its highs and lows do not necessarily occur at the same times as those due to the Moon. If the declination, or inclination of the Moon's orbit to the plane of the Earth's equator, is appreciable (the maximum is 28.5°), the two high-water bulges of the equilibrium tide will no longer be centered on the equator. An observer located anywhere other than the equator will therefore see two high waters of unequal height during a day.

Complications to the Equilibrium Tide. The simple equilibrium-tide concept is complicated in practice by such factors as the varying depth of the ocean, the existence and complex shapes of continents, and the CORIOLIS EFFECT. Because the tides are waves of very long wavelength, their motions are strongly affected by their interaction with the seafloor. In the deep ocean the tidal range rarely exceeds 0.5 m (1.6 ft), but in shallow coastal waters the tidal range increases, just as surf grows when it approaches a beach. This effect is reinforced in bays and estuaries whose natural period of oscillation is close to the tidal period. Tides in the Bay of Fundy, for example, have a range of 13.6 m (44.6 ft).

Friction with the seafloor is also important. The Earth rotates on its axis faster than the Moon revolves around it, and friction therefore drags the high-water bulge ahead of its equilibrium position directly beneath the Moon.

Tidal currents are also constrained by the continents surrounding the ocean basins. The Coriolis effect deflects currents to the right in the Northern Hemisphere and to the left in the Southern Hemisphere (see OCEAN CURRENTS); tidal currents therefore tend to move counterclockwise around ocean basins in the Northern Hemisphere and clockwise in the Southern Hemisphere. High water thus occurs at different times in different locations in an ocean basin. High-water information is commonly plotted on maps—called cotidal charts—that show lines connecting locations at which high water occurs at the same time.

Tieck, Ludwig [teek] Johann Ludwig Tieck, b. May 31, 1773, d. Apr. 28, 1853, was the most prolific and versatile writer of German ROMANTICISM. He wrote novels, plays, and stories and was an editor and translator. Along with Novalis and the brothers Schlegel, Tieck belonged to the first German romantic group in Jena.

Tieck's novels *William Lovell* (1795–96) and *Franz Sternbalds Wanderungen* (The Wanderings of Franz Sternbald, 1798) are after the manner of Goethe's *Wilhelm Meister* and deal with youth's search for an identity and social role. His plays range from such historicomythological works as *Karl von Berneck* (1793–95), *Genoveva* (1799), and *Kaiser Oktavianus* (1804) to the satirical comedies *Puss-in-Boots* (1797; Eng. trans., 1974), *The Land of Upside Down* (1798; Eng. trans., 1978), and *Prinz Zerbino* (1799).

Tieck's reputation rests ultimately on his stories. Some are based on medieval legends; others—like *Blond Eckbert* (1797; Eng. trans., 1974) and *Der Runenberg* (1804)—are free inventions that explore the incursion of the supernatural into ordinary life.

Tien Shan see TIAN SHAN

Tientsin see TIANJIN

Tiepolo (family) [tee-ay'-poh-loh] **Giambattista Tiepolo,** b. Mar. 5, 1696, d. Mar. 27, 1770, was the last great Italian painter in the Renaissance tradition. He created a style that combines flawless draftsmanship, total command of perspective, and monumental compositional structure with brilliant color and silvery light—a style so dazzling as to be equaled only by that of Paolo Veronese in the history of Italian art. Tiepolo's reputation for technical virtuosity in painting, drawing, and printmaking was so great that he was said to be capable of completing a picture in less time than it took others to prepare their paints. His output was enormous and he never lacked patrons; he was most appreciated in northern Italy, Germany (where he worked from 1750 to 1753), and Spain (1762–70), where he died.

By 1740, Tiepolo had acquired the final element of his mature style, a complete mastery of spatial illusion, which culminated in the *Transport of the Holy House of Loreto* (1743–44), the spectacular ceiling fresco painted for the Venetian Church of the Scalzi. This masterpiece was destroyed in 1915, but Tiepolo's freely painted oil sketch has been preserved (1743; Accademia, Venice). It records the bold foreshortening and spacious, asymmetrical design of the lost ceiling.

His prodigious inventiveness made Tiepolo the great-

Giambattista Tiepolo's Meeting of Anthony and Cleopatra *(c. 1745–50) is a detail from a series of monumental frescoes in the Palazzo Labia, Venice.*

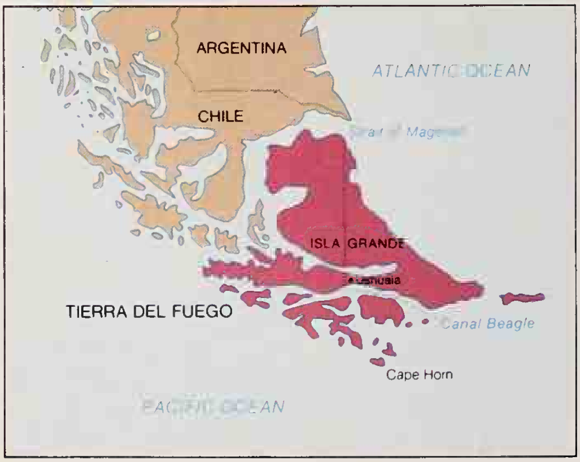
est monumental decorator of the century in secular as well as ecclesiastical commissions. In the Palazzo Labia in Venice, Tiepolo and Girolamo Mengozzi-Colonna, his frequent collaborator, envisioned *The Banquet of Cleopatra* (*c.*1745–50) as a theatrical event taking place behind a pierced screen of illusionistic architecture; this idea is rendered so convincingly that real and fictive space are virtually indistinguishable. At Würzburg, Tiepolo created costumes and a setting of such ravishing beauty that he transformed the depiction of an insignificant event in medieval German history, the *Marriage of Frederick Barbarossa* (1752; Residenz, Würzburg), into one of the greatest masterworks of the 18th century.

Tiepolo exercised his genius for spectacle even in his altarpieces and has therefore been accused of religious insincerity. But the tender pathos conveyed in the *Martyrdom of Saint Agatha* (1750; Staatliche Museen, Berlin) attests to the depth and truth of his faith.

Tiepolo trained his sons **Giandomenico Tiepolo**, b. Aug. 30, 1727, d. Mar. 3, 1804, and **Lorenzo Tiepolo**, b. Aug. 8, 1736, d. Aug. 8?, 1776, as painters; they continued his style.

Tierra del Fuego [tee-air'-uh del fway'-goh] Tierra del Fuego is a group of islands separated from the southern tip of the South American mainland by the Strait of Magellan. The eastern third of the archipelago belongs to Argentina (1989 est. pop., 58,881); the western two-thirds is Chilean (pop. unavailable). The islands are sparsely populated by three Indian tribes as well as by Chilean and Argentinian settlers. The total land mass of the archipelago is about 73,740 km^2 (28,470 mi^2). Isla Grande de Tierra del Fuego accounts for about two-thirds of the land area. On Isla Grande is the principal settlement, the Argentine city of Ushuaia. Mount Sarmiento, the islands' highest point at about 2,300 m (7,550 ft), is located to the west, where the mountains are an extension of the Andes range. Chief economic activities are petroleum extraction and sheep raising.

Ferdinand Magellan came upon the area in 1520; he named it "Land of Fire" (in Spanish, Tierra del Fuego) because he observed inhabitants carrying fires. In 1578, Sir Francis Drake sighted Cape Horn, the southernmost point of South America. The Argentine-Chilean boundary was fixed in 1881.



The plant forms and drooping shape of this bronze-base stained-glass table lamp, produced (c.1900) in the Tiffany Studios, epitomize Art Nouveau style. One of the leading American exponents of Art Nouveau, Louis Comfort Tiffany made major contributions to the decorative arts of the late 19th and the early 20th century. (Metropolitan Museum of Art, New York City.)

Tiffany, Louis Comfort Louis Comfort Tiffany, b. New York City, Feb. 18, 1848, d. Jan. 17, 1933, was the most notable American contributor to the Art Nouveau style. Although he was renowned for his work in stained and iridescent glass, his accomplishments ranged from painting, architecture, and interior design to such crafts as mosaic and jewelry. He was the eldest son of Charles L. Tiffany, founder of Tiffany and Company.

Tiffany's interest in the Arts and Crafts movement and in the writings of its mentor William Morris led him to found the decorating firm of Louis C. Tiffany and Associated Artists in 1881; within a year it was enormously successful. Tiffany designed interiors for New York City theaters, clubs, and private homes. His Veterans' Room (1880) in the Seventh Regiment Armory in New York City remains unchanged, as does his immense stained-glass curtain (completed 1911) in Mexico City's Art Nouveau Palacio de Bellas Artes.

Greatly impressed by French art glass, Tiffany hired American and European artisans in the 1890s to produce glassware. His term for the vases, lampshades, and decorative household objects that were made was *Favrile*, derived from the early French word for "handcrafted." In their asymmetrical shapes, floral patterns, and vivid, iridescent colors, these pieces are the epitome of Art Nouveau.

In 1904, Tiffany built a palatial summer home, Laurelton Hall, on Long Island, N.Y. The style was Islamic-inspired Art Nouveau; the villa's steel-frame construction and glass-paneled walls were architectural innovations.

Tiflis see Tbilisi

The tiger, with its strong legs and claws, is an able hunter but needs sufficient cover to attack fleet prey before they have time to escape. The tiger hunts by sight and hearing rather than smell.

tiger The tiger, *Panthera tigris*, is the largest and most powerful of the cat family, Felidae. Tigers prefer forests but are adaptable and range from the cold wastelands of Manchuria and Siberia to the thornbush of India and the hot bamboo jungles and rain forests of Malaysia. They were once found throughout southern Asia, but hunting and forest clearing have restricted their range and limited their numbers. The male tiger may stand 1 m (40 in) at the shoulder, have a head and body length of 2.7 m (9 ft) and a tail of about 90 cm (3 ft), and weigh from 180 to 270 kg (about 400 to 600 lb). Tigresses are smaller. The upper coat is usually reddish yellow to tawny, marked with blackish stripes; the underparts are whitish.

Tigers typically come out at night to stalk prey. They prefer large prey, bringing it down with their claws after a brief fast rush, but they also eat small animals. The males are usually solitary hunters. From one to six but usually two or three helpless cubs, weighing only about 1.3 to 1.8 kg (3 to 4 lb), are born after a gestation period of 98 to 109 days. They become independent at about 2 to 3 years. The average life span is 15 years.

tiger's-eye Tiger's-eye, a variety of rich golden yellow to brownish QUARTZ, is polished as a semiprecious ornamental stone to display its characteristic chatoyancy—a band of pearly luminescence resulting from reflection of light from parallel inclusions. The quartz originally contained fibers of crocidolite, a bluish asbestos; their alteration to iron oxides produced color banding. Silica subsequently replaced the iron oxides. In the similar blue-colored gem hawk's-eye, the crocidolite fibers were replaced by silica before alteration.

Tiger's-eye is a silky appearing, fibrous variety of quartz, ranging from golden yellow to brown, that is used extensively as an ornamental stone.

Tiglath-Pileser III, King of Assyria [tig-lath-pi-lee'-zur] Tiglath-Pileser III, d. 727 BC, king of Assyria (r. 745–727 BC), restored Assyria's imperial power after the chaos resulting from a plague, the evil omen of a solar eclipse (763), and the weakness of a royal family overthrown by a revolution in 745. As a result of the upheaval, Tiglath-Pileser replaced Ashurnirari (r. *c.*754–*c.*745). He campaigned successfully in 743 against the Armenian kingdom of URARTU, which had menaced the frontier. Defeating various coalitions of western states in Syria, his forces sacked Damascus in 732 and made Israel a vassal state. After an anti-Assyrian faction took over Babylonia in 734, Tiglath-Pileser seized (729) the Babylonian throne.

Tigranes I, King of Armenia [ty-gray'-neez] Tigranes I, also known as Tigranes the Great, *c.*140–*c.*55 BC, king of Armenia from 95, became one of the most powerful rulers in the Near East. He conquered large areas in Media, Syria, and Mesopotamia and built a new capital named Tigranocerta. The Romans, concerned by the threat from Tigranes' empire, sent an army against him in 69, defeating him in 66 with the help of his own son. Tigranes was permitted to keep his throne, but he was required to pay tribute to Rome.

Tigris River [ty'-gris] The Tigris River flows 1,900 km (1,180 mi) through southeastern Turkey and Iraq, draining an area of 373,000 km^2 (144,000 mi^2). With the EUPHRATES RIVER, the Tigris supplies water to the dry plain formerly called Mesopotamia.

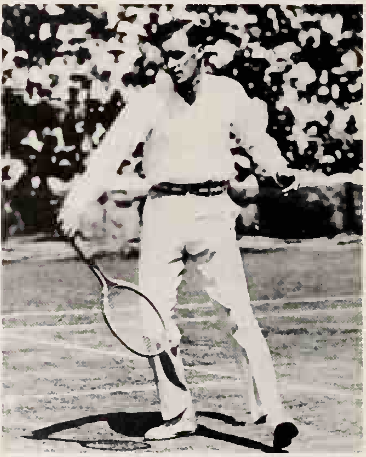
Navigable only between Baghdad and al-Qurnah, the Tigris begins at Lake Golcuk in east central Turkey and flows southeast past the Turkish city of Diyarbakir and through petroleum fields to Mosul in Iraq. The river continues south past a large irrigation barrage at Samarra to Baghdad, then southeast to al-Qurnah, where it joins the Euphrates to form the SHATT-AL-ARAB, which empties into the Persian Gulf. The Tigris provides irrigation waters for the cultivation of wheat, barley, millet, and rice. The Sumerians dug canals along the Tigris as early as 2400 BC, and the ruins of such ancient cities as CTESIPHON, NINEVEH, and Seleucia line its banks.

Tijuana [tee-hwah'-nah] Tijuana (1990 pop., 742,686) is a large city in northwestern Baja California, Mexico, about 20 km (12 mi) south of San Diego, Calif. An industrial center that produces textiles, electronics, and foodstuffs, Tijuana is a principal point of entry into Mexico for U.S. tourists. The city is a shipping center for wheat, barley, and wine grapes. Founded in the mid-19th century, Tijuana was notorious during the U.S. prohibition era for its gambling casinos and numerous bars.

Tikal [tee-kahl'] Tikal, in northeastern Guatemala, was the largest Maya city of the Classic era (AD 250–900). A small village in the first millennium BC, Tikal grew into a city of perhaps 75,000 at its height, covering some 100 km^2 (40 mi^2) bounded by defensive earthworks. By AD 400, the ruling dynasty of Tikal had bested its northern neighbor, Uaxactún, and adopted the symbolism and weaponry used at Teotihuacán, the powerful city-state in central Mexico. Although defeated in battle during the 6th century, Tikal rose to great power again in the 8th, then fell into ruins in the 9th and 10th centuries.

Tikal kings fashioned great programs of art and architecture to perpetuate the memory of their deeds. Their funerary pyramids became the focus of ancestor worship. Public works, including markets, reservoirs, and causeways, were regularly refurbished. Early rulers constructed buildings in the so-called Lost World group before making the Great Plaza the center of Tikal ritual, where some Early Classic kings were buried in the North Acropolis.

Tilden, Bill William Tatem Tilden, Jr., b. Germantown, Pa., Feb. 10, 1893, d. June 5, 1953, an American tennis star of extraordinary versatility and guile, was the world's dominant player during the 1920s. He won 10 Grand Slam singles titles in his career: 7 U.S. titles (1920–25, 1929) and 3 at Wimbledon (1920–21, 1930). He led the United States to 7 Davis Cup victories (1920–26) by winning 34 of 41 matches and after turning professional won two singles titles (1931, 1935), the last at an age (42) when most players have retired.



Bill Tilden, one of the most gifted and popular tennis players of the 1920s and '30s, won seven U.S., three Wimbledon, and two professional singles championships during his career. His cannonball serve, powerful ground strokes, and flair for the dramatic made his appeal widespread in Europe as well as in the United States.

Tilden, Samuel J. A leading corporation lawyer and Democratic politician, Samuel Jones Tilden, b. New Lebanon, N.Y., Feb. 9, 1814, d. Aug. 4, 1886, was governor of New York (1874–76) and the Democratic candidate for president of the United States in the contested election of 1876. He was admitted to the bar in 1841 and became corporation counsel for New York City in 1843. In 1846 he served in the New York State legislature and was a member of the state constitutional convention.

Samuel J. Tilden was governor of New York from 1874 to 1876. As state chairman of the Democratic party, he helped engineer the downfall of the corrupt Tweed Ring at Tammany Hall. He won a majority of the popular vote in the 1876 presidential election but was denied office on the basis of a dispute over electoral votes.

Tilden was a leader of the Free-Soil Barnburner Democrats in New York. Because the trend of the state's politics from the mid-1840s through the 1850s favored the rival pro-Southern or Hunker Democrats (see Hunkers and Barnburners), Tilden concentrated on his legal practice and built a large personal fortune. He gained political prominence while chairman of the New York State Democratic Committee (1866–74). Late in 1871 he moved to the forefront of the campaign to drive William M. Tweed's corrupt New York City political machine from power, establishing his credentials as a reformer.

In 1874, campaigning under a reform banner, Tilden was elected governor of New York. He attacked corruption in state politics and sought to bring about a general reduction of state expenditures. On national issues, he criticized Radical Reconstruction policy and advocated a hard-money policy. As the Democratic presidential nominee in 1876, Tilden won a 250,000-vote plurality but lost the election when the disputed electoral votes of four states were awarded by a special commission to Republican candidate Rutherford B. Hayes. Although Tilden believed he had been cheated out of the presidency, he acquiesced, largely withdrawing from active political life thereafter. He left most of his $6 million estate to New York City for a free public library.

tilefish Found from the Nova Scotia coast to the Gulf of Mexico, the perchlike tilefish, *Lopholatilus chamaeleonticeps*, is most abundant at depths of 80 to 360 m (260 to 1,200 ft). Tilefish may weigh up to about 22 kg (50 lb) and are bottom feeders. The back and sides of the adult fish are bluish gray, with yellow spots, and the face and underside are rose.

till and tillite [til, til'-yt] Till is a sedimentary deposit named by Scottish farmers before geologists understood its origin. Deposition of tills occurred during the four major ICE AGES of the Pleistocene Epoch, from about 2 million years ago to the present. Advancing glaciers (see GLACIERS AND GLACIATION) incorporated particles of rock and soil ranging in size from rock flour to boulders. The glacial advances acted like conveyer belts, bringing the particles to the terminus and depositing them as MORAINES. The resultant piles of glacial debris are known as drift, and till can be defined as nonsorted, unstratified drift deposited directly from glaciers. Examples of till deposits include the Bunker Hill and Breeds Hill DRUMLINS in Boston.

Till that is converted to solid rock is known as tillite. Tillite is distinguished from CONGLOMERATE by the surface texture of the pebbles and cobbles it contains. In tillite, these have facets caused by the abrasion of the rocks in the bottom layer of ice. Conglomerates, on the other hand, consist of rocks that have been rounded by water transportation. Almost all rock types are contained in tillite, the largest percentage being igneous and metamorphic rocks. The weathering of till or tillite produces an excellent tillable soil.

Tillamook [til'-uh-muk] The Tillamook were a North American Indian tribe of the northwest coastal region of what is now the state of Oregon. The southernmost of the Coast SALISH-speakers, they traditionally relied on salmon and other fish and shellfish for their subsistence; their well-developed fishing technology included nets, weirs, fishhooks, and harpoons. The most important social unit was the extended patrilocal family; tribal identities were vague. Family headmen existed, but there were no village chiefs or councils of elders, nor was there a rigid concept of land ownership. Small fishing sites were passed on to family clusters, but river rights were freely loaned. Reportedly the most powerful tribe on the Oregon coast before contact with Europeans, the Tillamook population was reduced from an estimated 2,200 at the time they were visited (1805) by the Lewis and Clark Expedition to only 200 members by 1850. The last full-blooded Tillamook died in the 1950s.

Tilley, Sir Samuel Leonard [til'-ee] Sir Samuel Leonard Tilley, b. Gagetown, New Brunswick, May 8, 1818, d. June 25, 1896, a prominent Canadian politician, helped form the Canadian Confederation. He entered New Brunswick's Legislative Assembly as a Reformer in 1850. As provincial premier (1861–65), Tilley was New Brunswick's leading advocate of Confederation. In 1864 and 1866–67 he attended the conferences that produced Confederation, and he helped bring his province into the union. Tilley was minister of customs (1867–73) and minister of finance (1873, 1878–85) in the first Canadian cabinet.

Tillich, Paul [til'-ik] Paul Tillich, b. Starzeddel, Germany, Aug. 20, 1886, d. Oct. 22, 1965, is considered one of the most creative and influential philosopher-theologians of the 20th century. Through his many writings and lectures, Tillich's lifework presents a religious interpretation of all culture that remains unsurpassed.

Tillich represented in his early training a union of traditional Lutheran piety and liberal German idealistic culture. As a chaplain in the German army during World War I, Tillich experienced both the reality and the universality of conflict and death and also the destruction of that same cultural unity. He became, in his subsequent career as a university professor in Germany, the intellectual leader of a group devoted to "religious socialism" and wrote several important pieces on politics, society, and history, including *The Socialist Decision* (1932). When the National Socialists came to power in 1933, Tillich's clear opposition to their ideology and policies and, above all, to their early persecution of Jews led to his dismissal (1933) from his professorship at the University of Frankfurt and his subsequent emigration to the United States. He taught first at Union Theological Seminary (1933–55) in New York, then at Harvard University (1955–62), and finally as Nuveen Professor of Theology at the University of Chicago Divinity School (1962–65). In the second half of his life Tillich became the leading philosophical and theological figure in the United States.

Tillich's two central concepts in his theology and cultural analyses are on the one hand the idea of the "unconditional"—the divine ground or power of being and meaning—and on the other hand the idea of "ultimate concern." In *Dynamics of Faith* (1957) and in his most important work, *Systematic Theology* (3 vols., 1951–63), he argues that the holy, sacred, and ultimate ground or source of all life is the direct concern of religious faith; in the language of religion, the ultimate is God. Indirectly, then, God is the object of the quest of philosophy—that unity of subject and object, of thought and being, which philosophical inquiry both presupposes and seeks (that is, "Being-Itself") but cannot, without the help of religion, find. For Tillich religion was the "substance" of culture. Thus, although cultural life and history itself have evidenced a distorted, self-destructive character, the "unexpected" has happened and will continue to happen. The living God, the creative power of being and meaning, has manifested itself in the new Being, centered in Jesus as the Christ, accepting the unacceptable, overcoming separation and thereby destruction and despair, and providing the conditions with which the anxieties and the terrors of the human state are conquered and the creative possibilities of the human being are opened.

Tillman, Benjamin Ryan [til'-muhn] Benjamin Ryan Tillman, b. Edgefield County, S.C., Aug. 11, 1847, d. July 3, 1918, a South Carolina governor (1890–94) and U.S. senator (1895–1918), was a spokesperson for southern agrarianism and a vitriolic racist. He became prominent politically in 1885, when he began organizing South Carolina farmers to overthrow the old-guard Democrats who controlled state politics. Tillman's angry attacks on the Bourbon Democrats helped him win two terms as governor. His accomplishments included tax reform, expansion of the state railroad commission's powers, and establishment of Clemson College—an agricultural school—and Winthrop College for women. Tillman's influence also meant that the new state constitution of 1895 included a number of Jim Crow laws and virtually disenfranchised African Americans.

In the Senate, "Pitchfork Ben" soon won national notoriety for his agrarian radicalism and his racism. In 1906 he helped secure passage of the Hepburn Act regulating railroad rates. Ill health and disagreements with allies gradually weakened his influence from about 1902.

Tilly, Johann Tserclaes, Graf von [til'-ee, tsair-klahs'] Johann Tserclaes, Graf von Tilly, b. February 1559, d. Apr. 30, 1632, fought in the service of Bavaria and the Holy Roman emperor during the Thirty Years' War. Tilly began his army career in a Spanish regiment and served under Alessandro Farnese during the Dutch Revolt. Commanding the armies of Bavaria and the Catholic League at the beginning of the Thirty Years' War, he defeated (1620) the Bohemians at the White Mountain, conquered the Palatinate, and defeated (1626) Christian IV of Denmark at Lutter. In 1631, commanding the combined Bavarian and imperial armies, Tilly was defeated by Gustav II Adolf of Sweden at Breitenfeld, and the Swedes then advanced into Bavaria. Tilly introduced modern methods of warfare into Germany and was among the best commanders of his age. His reputation suffered from the sacking and burning of Magdeburg by his troops in 1631, acts that resulted in the loss of an estimated 20 to 25 thousand lives.

Tilsit, Treaties of [til'-zit] During the Napoleonic Wars the Treaties of Tilsit ended the War of the Third Coalition—in which Russia, Prussia, and Austria were allied against Napoleonic France—and gave Napoleon I almost total control over Europe. Having defeated the Russians at Friedland on June 14, 1807, Napoleon opened negotiations with Emperor Alexander I on June 25 near the East Prussian town of Tilsit (now Sovetsk, in the USSR); later, King Frederick William III of Prussia also took part.

Under the treaty signed on July 7, France made peace with Russia, which, in turn, promised (covertly) to mediate between France and Britain and to ally with the French if the British refused mediation. By the treaty of July 9 most of Prussia's territory west of the Elbe River became part of the French-controlled Kingdom of Westphalia, and its Polish provinces were ceded to the newly created Duchy of Warsaw. Prussia was also obliged to reduce the size of its army and to join the Continental System against Britain. The peace of Tilsit was abruptly shattered when Napoleon invaded Russia in 1812.

Timbuktu [tim-buhk-too'] Timbuktu (French: Tombouctou), an administrative city in central Mali and a historic trading center, lies at the junction of trade routes on the southern edge of the Sahara just north of the Niger River. The population is 31,925 (1987). Salt trading is the principal activity.

Timbuktu, founded in the 11th century by Tuaregs, became part of the Mali kingdom in the 13th century. From 1468 to 1591, Timbuktu developed under Songhai rule into an important cultural center, as well as a commercial hub where gold, slaves, and salt were traded. After Morocco conquered the city in 1591, Timbuktu declined. The French established an outpost there in the 1890s, but the city never regained its past glory. It became part of Mali in 1960.

Time The first modern weekly newsmagazine, *Time* remains the leader in its field with a circulation of nearly 4.5 million. Started in 1923 by Henry R. Luce and Briton Hadden, *Time* sought to attract the busy reader by organizing news into compartments and presenting and analyzing it in a distinctive narrative style. It has come to epitomize group journalism, in which teams of researchers, writers, and editors prepare articles. Long noted for its Republican and pro-Chiang China biases, *Time* adopted (1964) a more liberal stance under its second editor-in-chief, Hedley Donovan.

time The experience of time, or of time duration, has received great attention in literature and philosophy. The experience varies among individuals and, because of its subjective nature, may appear to be inconsistent even in one individual. In scientific work, a numerical measure is used to order observations of events. If "now" is assigned the numerical value zero, then it is usual to assign earlier times negative values and later times positive values. To obtain a time scale, some periodic phenomenon that has repetitions occurring at a uniform rate that may be subdivided and counted must be used.

Modern Concept of Time. Before the 20th century it was assumed as self-evident that a single, universal, uniform time scale existed. For two events that are widely separated in space, it had been assumed that there is no difficulty in defining the meaning of the concept of simultaneity—namely, if to one observer the events appeared to occur simultaneously, then all other observers would agree that the events were indeed simultaneous. Albert Einstein, however, early in the 20th century, recognized that because of the universal constancy of the speed of light the measurement of time depends on the motion of the observer.

Consider events A and B separated in space, which appear simultaneous to one observer; to another observer, then, who is in motion relative to the first, the event A may occur before or after B, depending on the direction of the relative motion between the two observers. Thus, in the modern view, time is no longer absolute, but dependent on the relative motion of observers making the time measurements. According to the theory of relativity, time is but one aspect of a more general four-dimensional space-time continuum, in which events occur in the universe. Time and space are different aspects of this underlying four-dimensional continuum. Frequently time is described as a fourth dimension.

Time Scales. From earliest times the rotation of the Earth (or the apparent location of the Sun in the sky) has been used to establish a uniform time scale. In order to specify a date, using the apparent motion of the Sun as a time scale, days must be counted from some reference date (see CALENDAR). In addition, a clock is used to measure fractions of a day.

Time derived from the apparent position of the Sun in the sky is called apparent solar time. Because of the eccentricity of the Earth's orbit around the Sun and the inclination of the Earth's rotation axis to the orbital plane, apparent solar time is not a uniform time scale. These effects can, however, be calculated and corrections applied to obtain a more uniform time scale called mean solar time. Universal Time (UT0) is equivalent to mean solar time at the Greenwich Meridian (GREENWICH MEAN TIME, or GMT). Observations of the apparent motion of a distant star may be used to obtain yet another time scale used in astronomy, called sidereal time.

Additional small deviations from uniformity of UT0 may be traced to small effects, such as the wandering of the Earth's polar axis and other periodic fluctuations of the Earth's rotation; accounting for these effects leads to additional, even more uniform, time scales (UT1 and UT2).

Ephemeris time is determined by the orbital motion of the Earth about the Sun and is not affected by fluctuations in the Earth's rotation. Astronomical observations may be used to determine ephemeris time to an accuracy of roughly 0.05 seconds, averaged over a nine-year period.

Atomic Timekeeping. The invention of the quartz crystal oscillator and of the ATOMIC CLOCK makes possible the measurement of time and frequency more accurately than any other physical quantity. Thus, in addition to astronomical time scales, there are other time scales such as atomic time (AT), based on the microwave resonances of certain atoms in a magnetic field. Counting the cycles of an electromagnetic signal in resonance with cesium atoms provides an accuracy of a few billionths of a second over short intervals of a minute or less.

Since about 1960 a number of laboratories around the world have cooperated in comparing their atomic time scales, leading to the formation of a weighted average of the various atomic time scales, which is now disseminated to the public as Universal Coordinated Time (UTC). In order to keep UTC in agreement with the length of the day, seconds are occasionally added to or deleted from the atomic time scale (a "leap second"). By international agreement, UTC is maintained within 0.7 seconds of the navigator's time scale, UT1.

Defining the Second. The advancement of precision in time measurement has resulted in redefinitions of the second. Prior to 1956, one second was defined as the fraction 1/86,400 of the mean solar day. From 1956 to 1967, it was the ephemeris second, defined as the fraction 1/31556925.9747 of the tropical year at 00h 00m 00s 31 December 1899. The second is currently defined as the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.

See **also:** CLOCKS AND WATCHES; TIME-REVERSAL INVARIANCE.

time and motion study see TAYLOR, Frederick Winslow

Time of Troubles In Russian history, the Time of Troubles was the period that followed the death (1598) of Tsar Fyodor I, the last ruler of the RURIK dynasty, and lasted until the crowning (1613) of the first ROMANOV. During Fyodor's reign (1584–98) real power lay in the hands of his brother-in-law, BORIS GODUNOV. Fyodor's half brother, Dmitry, was killed in 1591, possibly by order of Godunov, who became tsar when Fyodor died.

In 1604 a pretender who claimed to be Dmitry and who had the support of King SIGISMUND III of Poland appeared. This "false Dmitry" became tsar upon the assassination of Godunov's son and successor, Fyodor II (r. 1605). Dmitry's close ties with Poland, however, angered the Russian boyars. Led by Prince Vasily Shuisky, they rose and killed Dmitry. Shuisky became tsar as Vasily IV (r. 1606–10). In 1607 another pretender named Dmitry appeared, again with Polish support. Polish troops entered Moscow in 1610 in his defense, but he was killed. Sigismund attempted to place his own son Władysław on the Russian throne but then decided that he wanted to rule there himself; he succeeded only in uniting the Russians against the Polish invaders. Two more pretenders sought the Russian throne, but in 1613 a *zemsky sobor* (national council dominated by the boyars) unanimously elected as tsar 17-year-old Michael Romanov (see MICHAEL, TSAR OF RUSSIA).

time-reversal invariance A motion in which events appear in reverse order is said to be time reversed with respect to the original motion. If some motion is possible according to known physical laws, then the time-reversed motion is almost always possible. This possibility is true for motions caused by gravitational and electromagnetic forces, and it is said that these laws exhibit time reversal invariance or have time reversal as a basic symmetry. For example, it would be unusual to observe a real process in which an egg broken on the floor collects itself and flies up whole into a person's hand, as in a movie run backward. Nevertheless, according to known physical law such a process is not impossible, although it is too unlikely to expect it actually to happen. Movies of simpler processes, however, such as a spinning top or a vibrating bell, appear nearly normal when run backward.

The basic natural laws governing most elementary processes are invariant under time reversal; however, most natural processes themselves do not appear to be symmetric under time reversal. Complex systems generally develop in time toward a more probable state; this increase in likelihood is related to an increase of ENTROPY of the system.

Experiments with elementary particles test time-reversal invariance by observing processes in which elementary particles are produced, interact, and decay. Time-reversal invariance appears to be a valid symmetry for all processes except in the weak decay of K mesons (kaons).

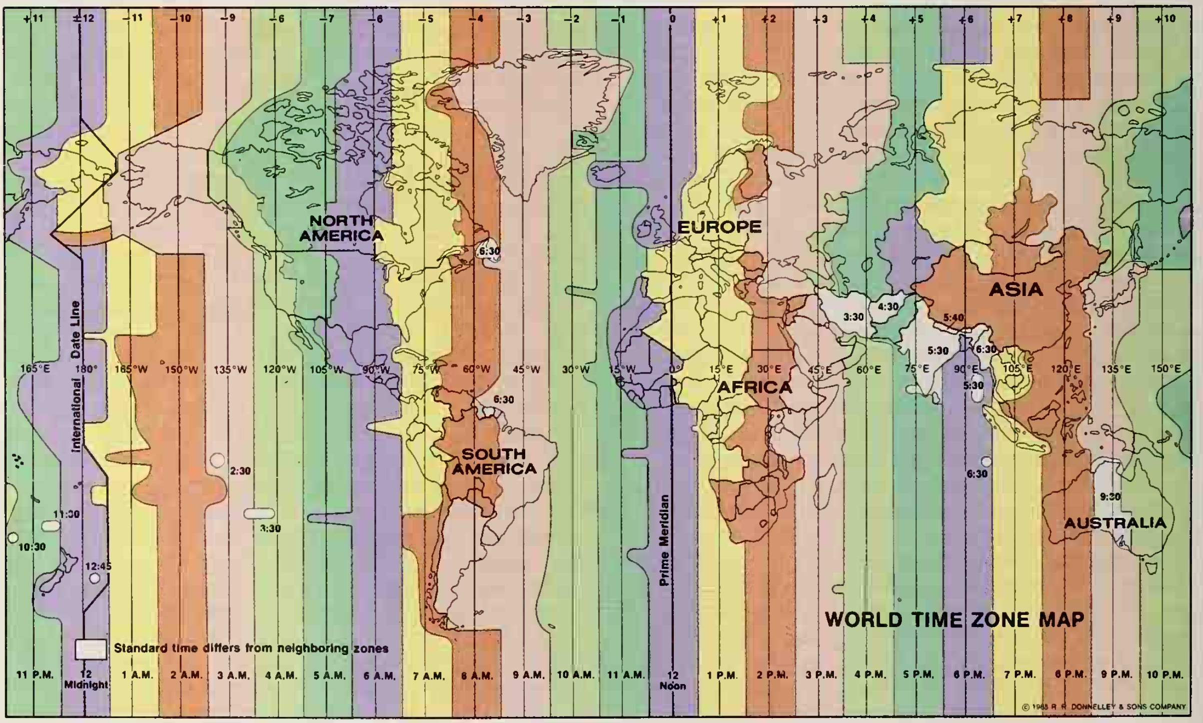
time-sharing Time-sharing is the simultaneous use of a central COMPUTER by independent access stations. Because of high processing speeds modern computers are often idle; in the time taken by a user to type a command, a computer can make thousands and even millions of computations. Time-sharing therefore makes use of this available time, by means of a central program that schedules the access of individual terminals into the main unit (see OPERATING SYSTEMS). Time-sharing may take place within a single business organization but is also practiced on much wider scales, with geographically dispersed terminals connected via cable or telephone lines to the central unit. Such access is often obtained by firms or other users who do not wish to purchase their own large computer systems.

time zone A time zone is a longitudinal strip of the Earth's surface, stretching from pole to pole and sharing the same time of day or night. The Earth requires 24 hours to make one complete rotation on its axis; thus the direct rays of the Sun pass through one degree of longitude every four minutes. To allow for time changes on an hourly basis, each time zone covers 15° of longitude in width. In practice, however, the zone boundary lines are drawn to accommodate political units. In addition, for various reasons a number of countries differ considerably from international practice in their time designations.

See also: GREENWICH MEAN TIME; INTERNATIONAL DATE LINE.

Times, The *The Times* of London, a newspaper founded in 1785 by John Walter as the *Daily Universal Register*, received its present name in 1788. During the 19th century the paper became the unofficial voice of the government regardless of the party in power. A continuing emphasis on book reviews led to the establishment in 1902 of the weekly *Times Literary Supplement. The Times* was purchased by Lord Thomson of Fleet (Roy Thomson) in 1966. Its publication was suspended for a year in late 1978 because of disputes over the introduction of a labor-saving computer-typesetting process that caused a reduction in the work force. Publication resumed in late 1979, and in 1981 *The Times* was purchased by the publisher Rupert MURDOCH.

International time zones to the west of the Prime Meridian (0° longitude) are progressively earlier; to the east they are later. The date moves one day forward for persons crossing the International Date Line from east to west, and one day back from west to east.



Timişoara [tee-meesh-wah'-rah] Timişoara (Hungarian: Temesvár) is a city in western Romania with a population of 261,950 (1983). Linked with the Danube in Yugoslavia via the Bega Canal, the city produces both industrial and consumer goods. Timişoara University (1962) is there, and landmarks include a 14th-century palace and two 18th-century cathedrals. First documented in 1212, Timişoara was a Hungarian border fortress until it was taken (1552) by the Turks. The Austrians captured the city in 1716, and it became part of Romania in 1920. The revolution that led to the overthrow of Romania's Communist government began in Timişoara in December 1989.

Timoleon [tim-oh'-lee-uhn] A Corinthian general, Timoleon, d. *c.*334 BC, was known as "the scourge of tyrants." After citizens of the Corinthian-colonized city of SYRACUSE appealed to Corinth for assistance in overthrowing the tyrant DIONYSIUS THE YOUNGER, Timoleon, sent to Sicily with an army in 344 BC, defeated Dionysius and established a modified democratic government in Syracuse. He subsequently defeated a Carthaginian invasion (341), and by 337 he had deposed the remaining tyrants of Greek Sicily.

Timor [tee'-mohr] Timor, an island in Indonesia, is the largest and easternmost of the Lesser Sunda Islands in the Malay Archipelago. The island covers 33,850 km^2 (13,070 mi^2). The people are Indonesian Malays. The mountainous island, rimmed by narrow coastal plains and swamplands, is divided into two provinces. West Timor is administered as part of Nusa Tenggara Timur, which includes nearby islands, and East Timor is administered separately as Timor Timur. Kupang and Dili serve as provincial capitals of West and East Timor, respectively. Most Timorese practice subsistence agriculture, but coffee, tea, rubber, coconuts, and sandalwood are exported.

Portugal began trading with Timor in 1520, and treaties (1860, 1914) between the Portuguese and the Dutch divided the island in half. Dutch-controlled West Timor joined recently independent Indonesia in 1950, and East Timor remained a Portuguese colony. After the Portuguese departed in 1975, Indonesia intervened to prevent Fretelin, the independence movement, from gaining control of the area. The ensuing struggle caused widespread economic hardship, and the United Nations passed several resolutions condemning the Indonesian government's formal incorporation of East Timor as the 27th province of Indonesia in July 1976. After 1980, conditions improved somewhat, and the area was opened to tourism and foreign investment in January 1989, although sporadic fighting continued in the mountainous interior.

timothy Timothy is the common name for about ten species of perennial plants of the genus *Phleum* in the grass family, Gramineae. These grasses are native to the cool and temperate regions of Europe and Asia, although they became naturalized in North America after being introduced by the colonists. The stalk grows to a height of 1.5 m (5 ft), with leaves 30 cm (1 ft) long, and terminates in dense spikes of bearded spikelets, which may grow to 15 cm (6 in). Commercially this grass has been widely grown for hay.

Timothy, Epistles to The two Epistles to Timothy, in the New Testament of the Bible, are classified with the Epistle to Titus as the Pastoral Epistles. They are addressed by Saint Paul to his companion, Timothy, leader of the church at Ephesus (1 Tim. 1:3), who is known from Acts and other epistles. The letters are pastoral in that they urge Timothy to combat false teaching and guide his people in preserving the truth; they also give detailed instructions concerning the duties of bishops, deacons, widows, and other Christians. Many scholars think that these letters were written about AD 100 in Paul's name, rather than by Paul himself, because the language differs from that of the other epistles.

Timothy, Saint Saint Timothy was a young assistant and disciple of Saint PAUL in the missionary activities described in the New Testament. His name appears with Paul's in the greetings of seven of the Pauline epistles. According to tradition, he was made bishop of Ephesus, where he was martyred (AD 97) when he protested orgies accompanying the worship of Artemis. Feast day: Jan. 26 (formerly Jan. 24; Western); Jan. 22 (Eastern).

Timur [tee-moor'] Timur, or Tamerlane, b. Apr. 8, 1336, d. Feb. 18, 1405, a Mongol conqueror, was widely re-

Timur, or Tamerlane, enters his capital city of Samarkand in this 14th-century Persian miniature. This conqueror, who acclaimed descent from Genghis Khan, led his Turko-Mongol armies in brilliant military campaigns against India, Persia, and the Ottoman Empire. Timur's vast empire collapsed shortly after his death in 1405.

garded as the military equal of the earlier Genghis Khan, whom Timur—probably falsely—claimed as a direct ancestor. Timur, however, was a different kind of military tactician, striking quickly and often without plan, and he made no contribution to the governance or legal systems of the peoples he conquered. His cruelty went beyond that of any other Mongol khan or ruler—he was responsible for the deaths of hundreds of thousands of people. His name also appears as Tamburlaine or Timur Lenk.

Timer belonged to an Islamic, Turkized Mongol tribe in Transoxiana (today's Uzbekistan). By 1370 he had become the ruler of this region, making Samarkand his capital. Having conquered (by 1381) Khorezm and Herat, Timur began a successful onslaught against the rulers and peoples of the Middle East and Transcaucasia, although he was diverted several times by military threats from Tokhtamysh, his former ally and khan of the GOLDEN HORDE. During 1392–96, he completed his conquest of Iran, occupied Baghdad, and routed the Golden Horde. In 1398 he invaded India and occupied Delhi. In 1400, Timur invaded Syria and Anatolia and inflicted (1402) a devastating defeat on the Ottoman sultan Bayezid I at Ankara.

Timur died during a vain attempt to conquer China. Turko-Mongol influence subsequently declined, although the brief rule of Timur's descendants, the Timurids, brought a period of cultural grandeur.

tin Tin, a solid, rather unreactive metal, in Group IVA of the periodic table, has an atomic number of 50 and an atomic weight of 118.69. Its chemical symbol, Sn, is derived from *stannum*, the Latin word for "tin." BRONZE, an alloy of copper and tin, has been known since 2500–2000 BC (the BRONZE AGE). The first inclusion of tin in bronze was probably an accidental result of tin ore being found in copper ore; pure tin was probably obtained at a later date.

Tin is relatively rare (about 0.001% in the Earth's crust) and is obtained from its chief ore, cassiterite (SnO_2), a naturally occurring tin oxide, by various refining methods, including carbon reduction. Important ore deposits are found in Malaysia, Indonesia, Zaire, Nigeria, and Bolivia.

Physical Properties. White tin, the element's familiar allotropic form (see ALLOTROPE), is a silvery white, soft, ductile metal that melts at 232° C and boils at 2,270° C. Below 13.2° C pure metallic tin slowly converts to gray tin, a different crystalline form that is less dense and lacks the metallic properties of white tin. Gray tin has few, if any, uses.

Chemical Properties. In its chemical compounds, tin exhibits two common oxidation states, +2 and +4. Tin dissolves in hydrochloric acid, reacting to yield stannous chloride, $SnCl_2$, and hydrogen gas. Concentrated nitric acid oxidizes tin to the +4 oxidation state, forming stannic oxide, SnO_2. A strong base, such as sodium hydroxide, dissolves tin to form a stannate, a chemical SALT.

When exposed to the atmosphere and moisture, tin forms a protective oxide coating that resists further corrosion. When tin reacts with excess chlorine gas, stannous chloride, $SnCl_2$, a colorless liquid and electrical conductor, is formed. The reaction of tin with hydrofluoric acid yields stannous fluoride, SnF_2, a white, water-soluble compound that is added to toothpaste to help prevent tooth decay.

Alloys. Tin is a major component in many useful ALLOYS. When mixed with tin to form bronze, copper is easier to cast and has superior mechanical properties. Pewter is an alloy of tin hardened with antimony and copper. Tin alloys are also used in solder, bearings, and type metals. Commonly used solders are alloys of tin and lead.

Tinplate. Because of its resistance to corrosion, tin is used as a protective coating for other metals that corrode easily. Most of the tin imported into the United States is used for plating steel. Tin cans are actually steel cans with a thin coating of metallic tin. Once a portion of the tin coating is removed, and steel is exposed to the atmosphere and moisture, rapid corrosion begins. The tinplate also prevents the organic acids contained in many foods from reacting with the steel can. The plating of the steel with tin is accomplished either by ELECTROLYSIS or by dipping the steel into molten tin.

Tin Pan Alley Originally, *Tin Pan Alley* referred to the popular songwriting trade centered in New York City, but eventually the phrase came to include the entire American pop-music industry from the 1880s to the 1950s. According to legend the term was coined between 1900 and 1903 by songwriter-journalist Monroe Rosenfeld, who was inspired by the clashing sounds of pianos and singing voices from countless open windows on New York City's West 28th Street, once the site of dozens of music publishing companies.

Aggressive marketing of popular sheet music began in the 1880s, and by the 1890s sales of hit songs had reached the millions. At first, most popular songs were introduced on the musical stage, but in the 1930s radio and sound movies began playing an increasing role, and phonograph records replaced sheet music as the measure of sales success. Control of America's mainstream popular music remained with a few major corporations until the advent of ROCK MUSIC in the 1950s.

See also: MUSIC HALL, VAUDEVILLE, AND BURLESQUE; MUSICAL COMEDY.

tinamou [tin'-uh-moo] A tinamou is a ground-dwelling game bird found from southern Mexico to southern Argentina in diverse habitats from lowland jungles to treeless Andean slopes. The more than 30 species, related to flightless rheas, make up the family Tinamidae, the sole family of the order Tinamiformes. Quail-sized to chicken-sized, tinamous generally have small heads; thin necks; short, rounded wings; short tails; and thick legs with three, short front toes and sometimes a fourth, elevated hind toe. The plumage—usually gray or brown and often streaked and spotted—provides excellent camouflage. Tinamous feed chiefly on vegetable matter and insects.

The variegated tinamou, found in tropical and subtropical forests and thickets, feeds exclusively on vegetation.

Tinamou eggs are large, glossy, and beautifully colored. Males usually build the nest, incubate the eggs, and care for the young.

Tinbergen, Jan [tin'-bair-guhn] The Dutch economist Jan Tinbergen, b. Apr. 12, 1903, shared (1969) the first Nobel Prize for economics with Ragnar Frisch. Tinbergen, a graduate (1929) of Leiden University, received the award for constructing econometric systems—developing and using mathematical models to analyze and structure behavior.

A professor (1933–73) at the Netherlands School of Economics, Tinbergen served (1945–55) as director of the Dutch central planning bureau. His books include *Shaping the World Economy* (1962) and *Development Planning* (1967).

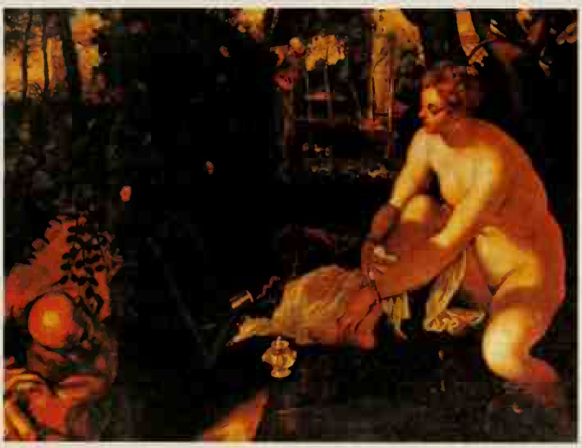
Tinbergen, Nikolaas The Dutch zoologist and ethologist Nikolaas Tinbergen, b. Apr. 15, 1907, d. Dec. 21, 1988, was a pioneer in the study of animal behavior under natural conditions and shared with Konrad Lorenz and Karl von Frisch the 1973 Nobel Prize for physiology or medicine. Tinbergen analyzed specific stimuli that elicit specific animal responses. His works include *The Study of Instinct* (1951), *Social Behavior in Animals* (1953), *Animal Behavior* (1965), and *The Animal in Its World* (1973).

Tinguely, Jean [tan-glee'] Jean Tinguely, b. May 22, 1925, d. Aug. 30, 1991, was an internationally known Swiss kinetic sculptor. Salvaging discarded machine parts, Tinguely recycled them in elaborate, sometimes immense works of art. They are powered by electric motors, and their moving parts make satirical comment on the complexity and dehumanization of the machine age. Art itself was one of Tinguely's targets—some of his machines employ pencil and paper to produce "drawings" of an abstract sort. He designed his large *Homage to New York* (1960) to destroy itself in the garden of New York City's Museum of Modern Art, which it did, although only partially. Tinguely was considered to be a contemporary exponent of the disruptive, "antiart" spirit of Dada.

Tintoretto [teen-toh-ret'-toh] Nicknamed Tintoretto—"Little Dyer"—in reference to his father's trade, Jacopo Robusti, b. *c.*1518, d. May 31, 1594, produced some of the greatest glories of 16th-century Venetian painting. Even in his earliest known works, Tintoretto displayed a new and unique vigor. Some of his characteristics have been called Mannerist; these include his weaving together of figures into an elaborate pattern, his tendency to direct the viewer's eye rapidly through the space of a picture to a high and off-center vanishing point, and his dramatic counterpoint of light and dark (chiaroscuro). Tintoretto rarely, however, used these devices merely as demonstrations of his virtuosity in producing the clever, graceful, and startling effects often associated with Mannerism. In planning compositions, he arranged small, draped figures on a miniature stage so that he could manipulate both lighting and perspective. The use of a wide, square-ended brush enabled him to produce an extremely large number of paintings with unprecedented speed.

Tintoretto's most extensive cycles of paintings were made for the Scuola of the Confraternity of San Rocco and for the Ducal Palace, both in Venice. His work at the Scuola began in 1565 and continued, intermittently, to 1587. On the ceiling of another room he painted 13 Old Testament events, among which *Moses Striking Water from the Rock* is especially notable for its illusionism. On the walls of the same room he depicted 10 complementa-

Susanna and the Elders *(c.1550), by the prolific Venetian painter Tintoretto, is judged to be the finest of his three versions of the Old Testament episode. (Kunsthistorissches Museum, Vienna.)*



ry occurrences from the New Testament. In the Ducal Palace, Tintoretto depicted a huge battle scene, the *Siege of Zara* (1584–87); a vast *Paradise* (1588); and many other paintings on religious, historical, mythological, and allegorical themes. Three of his most famous paintings deal with the patron saint of Venice, Mark the Evangelist: *Miracle of the Slave* (1548), *Transport of St. Mark's Body* (1562–66)—both at the Accademia, Venice—and *Discovery of St. Mark's Body* (1562–66; Brera, Milan).

Tippecanoe, Battle of [tip-uh-kuh-noo'] In the Battle of Tippecanoe (Nov. 7, 1811), Indiana territorial governor William Henry HARRISON, with 1,000 U.S. regulars and militiamen, defeated the Shawnee Indians on the Tippecanoe River near present Lafayette, Ind. The Indians were led by the SHAWNEE PROPHET, brother of their chief, Tecumseh. Harrison's men burned the Indians' chief village, the Prophet's Town, and then withdrew. Although it was indecisive, the battle made Harrison a national hero.

Tipperary Tipperary, a region in southern Ireland in the province of Munster, has an area of 4,254 km^2 (1,643 mi^2) and a population of 136,649 (1986). Clonmel (1981 pop., 12,407) and Tipperary (1981 pop., 4,984) are the major towns. Dairying is the main economic activity, but the cultivation of oats and potatoes, cattle raising, food processing, slate quarrying, and coal mining are also important. The Rock of Cashel, a one-time seat of the kings of Munster, is the most notable landmark.

Tipperary was dominated by the Butler family from 1185 to 1715. Today it is divided administratively into the counties of North Riding and South Riding.

Tippett, Michael [tip'-it] The English composer Michael Kemp Tippett, b. Jan. 2, 1905, creates music with a strong humanist message, in a style that is contemporary and yet firmly in the symphonic mainstream. His four operas—*The Midsummer Marriage* (1955), *King Priam* (1962), *The Knot Garden* (1970), and *The Ice Break* (1977)—composed to his own librettos, are among the most important of the late 20th century. Tippett's Third Symphony (1972) makes references to Beethoven's Ninth Symphony; his Fourth Symphony (1977) is a virtuoso piece composed for the Chicago Symphony. Among his other important works are the oratorio *A Child of Our Time* (1944) and the Concerto for Double String Orchestra (1939), as well as string quartets and piano sonatas. Tippett was knighted in 1966.

Tippu Sultan, Sultan of Mysore [tip'-oo, my-sohr'] Tippu Sultan (also Tippoo Sahib and Tibu Sahib), b. *c.*1750, d. May 4, 1799, sultan of Mysore (1782–99) in southern India, resisted British conquest for many years. Having studied Western military operations, Tippu commanded the troops of his father, HYDER ALI, in battles against neighboring states. He defeated the British in the Second Mysore War (1780–84). Clashing again with the British (1789–92), he scored impressive initial successes but finally was forced to give up half his holdings. In the Fourth Mysore War (1799), he died in battle, and his empire was destroyed.

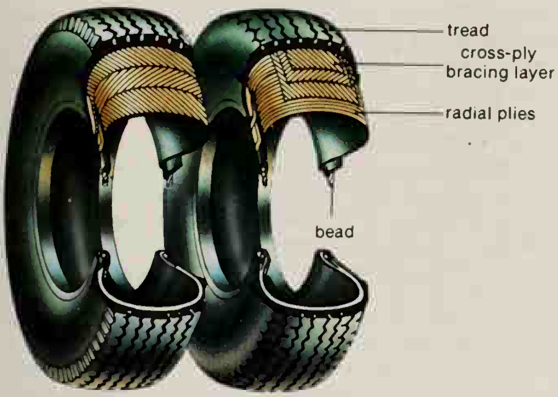
Tiradentes [tee-rah-then'-tuhs] Joaquim José da Silva Xavier, or "Tiradentes," b. Nov. 12, 1748, d. Apr. 21, 1792, was a forerunner of Brazil's independence. A sometime merchant and militia officer, he earned his nickname, which means "tooth puller," by working as an amateur physician and dentist. An admirer of republican ideas, he became (1788) a leader of the Inconfidência Mineira, an abortive revolt against Portuguese rule, but was imprisoned in 1789. Tiradentes was hanged and quartered in Rio de Janeiro.

Tiranë [tee-rah'-nuh] Tiranë, the capital and largest city of Albania, lies in the west central part of the country, about 30 km (20 mi) from the Adriatic coast. The population is 238,100 (1989 est.). A major industrial center, the city produces textiles, wood items, cigarettes, shoes, and dairy products; coal is mined nearby. Tiranë is linked by rail with Durrës, the chief port of Albania. The city's historic center consists of Skanderbeg Square, where the Etehem Bey Mosque (1819) is located. Most of the city, however, has a modern appearance. Cultural institutions include the state university (1957) and several museums. Founded in the 17th century by a Turkish general, Tiranë became the capital of Albania in 1920.

tire Tires are rubber-and-fabric devices that, when attached to the wheels of a vehicle, provide the contact between the vehicle and the road surface; tires also support the weight of the vehicle. They may be either solid or pneumatic (air-filled) in structure, with the latter by far the most prevalent today. Compressed air within the tire carries 90 percent of the load, with the tire's complex structure of rubber and fabric carrying the remaining 10 percent.

History

The first pneumatic tire, made from several layers of rubber-saturated canvas, was patented in 1845 by Robert W. Thomson. John DUNLOP patented (1888) a pneumatic tire for bicycles and formed a company for manufacturing tires for bicycles and automobiles. The tires in use by 1900 were called balloon tires; they had round cross sections, separate inner tubes, and rubber-coated, cotton-cloth covers. Treads, which alleviated the danger of sideslip, were introduced 10 years later. Layers of reinforcing cord date from the 1920s; whitewalls followed in 1929. The 1930s saw the introduction of synthetic materials. Separate inner tubes were eliminated in 1954.



A cross-ply tire (left) *has layers of fabric with diagonal cords. The layers retain strength while being stretched in different directions. A radial tire* (right) *has cords that run directly across the tire. This provides pliability but no directional stability, which comes from a belt of cords (cross-ply bracing layer) beneath the tread.*

Construction

The tread of the tire grips the road surface, and the supporting sidewalls run from tread to wheel rim. Tread patterns are especially important when the road is wet. Continuous channels from the center to the edge of the tread direct the water outward. Otherwise, water would form a wedge and cause the tire to lift off the road. This so-called aquaplaning phenomenon is one reason that smooth tires are dangerous in wet conditions. Snow tires and off-highway tires have deeper treads or separate cleats.

A tire's sidewalls flex up and down, helping cushion the vehicle from road irregularities, yet they must be relatively rigid horizontally in order to transfer loads of steering, braking, and acceleration. At their innermost edges, sidewalls meet the tire's beads (hoops of steel wire covered with hard rubber). Each bead reinforces the interface between the tire and wheel-rim and fixes the tire's inner diameter.

Reinforcing cords, which give the tire its strength, are arranged beneath the tire's surface. The three classes of modern tires can be distinguished by the direction of the cords. A bias-ply tire, the earliest, has two or more plies of cord running across the tire at an angle, or bias, from the tire's centerline. In a belted-bias tire, reinforcing belts are placed between the plies. A radial tire has reinforcing cords running hoop-fashion from bead to bead. Like a bias-belted tire, a radial has reinforcing belts under its tread, but radial belt cords are angled closer to the tire's centerline. The lack of bias sidewall reinforcement makes a radial's sidewalls more flexible. This gives the tread a better grip and longer life.

Tire construction begins with the sidewall. The different rubber compounds necessitated by the different requirements of each part of the tire are brought together to form sidewall-tread-sidewall strips. Beads are formed from wound and rubber-coated steel wires. Steel or synthetic-fiber fabric is rubber-coated and cut either at an angle or straight across, depending on tire type. All these materials are assembled for hand lay-up on a rotating, collapsible drum. Next, the beads and tread-sidewall strip are added. Finally, a heated press molds the tread pattern and vulcanizes the rubber.

Tiresias [ty-ree'-see-uhs] In Greek mythology Tiresias was a blind Theban soothsayer. According to one legend Athena blinded him when he accidentally came upon her bathing. His mother, the nymph Chariclo, begged for mercy; so Athena gave him the power of prophecy, as well as a golden staff to guide him in walking. Another tale relates how Tiresias, who had been changed into a woman and then back into a man, was asked to settle a quarrel between Zeus and Hera about which sex enjoyed love more. He said woman, angering Hera, who then blinded him. Zeus compensated him by giving him long life and the gift of prophecy, but Hera decreed that no one would believe his predictions.

Tirol see TYROL

TIROS The original TIROS (Television and Infrared Observation Satellite) series of ten weather satellites, launched by the National Aeronautics and Space Administration (NASA) between 1960 and 1965, was developed to test television cameras and Sun-angle and horizon scanners for use in meteorology (see SATELLITE, ARTIFICIAL). Although begun on an experimental basis, the program soon became semioperational. Each of the satellites carried two television cameras, one with a wide-angle lens and the other providing a narrower field of view in greater detail.

The next generation of satellites in the program, a series of nine ESSA (Environmental Science Service Administration) craft launched between 1966 and 1969, formed the Tiros Operational System (TOS), relaying cloud-cover images to simple stations located in several countries. The ESSA satellites used advanced cameras that had been tested on early entries in NASA's NIMBUS program, a series designed for more wide-ranging scientific studies in meteorology.

ESSA was followed by the ITOS/NOAA series, initiated by the launching of *TIROS-M* in 1970. Once in orbit, the satellite was renamed *ITOS-1* (Improved Tiros Operational Satellite-1). The five satellites that followed it into orbit from 1970 to 1976 were named NOAA, for the National Oceanic and Atmospheric Administration, ESSA's successor. Each craft provided day-and-night global coverage every 12 hours and could either relay images and radiometric data automatically or store them for later playback. Each also carried advanced instruments, such as radiometers for obtaining vertical temperature profiles of the atmosphere.

The third generation of satellites in the program began operation with the launching of *TIROS-N* in 1978, the first in a series of eight planned polar-orbit meteorological satellites. Succeeding entries in the series have continued the NOAA numbering sequence, beginning with *NOAA-6* in 1979. These satellites are equipped with more sophisticated cameras and radiometers as well as infrared, stratospheric, and microwave sounders. In addition, they can provide readings of sea-surface temperatures, identify snow cover and ice at sea, and measure particle densities in the upper atmosphere in order to predict the onset of solar disturbances. Operated by the National Oceanic and Atmospheric Administration, they and the Nimbus and Geostationary Operational Environmental Satellites (see GOES) are essential units within the U.S. National Operational Meteorological System (see METEOROLOGY).

Tirpitz, Alfred von [tir'-pits] Alfred von Tirpitz, b. Mar. 19, 1849, d. Mar. 6, 1930, created the German High Seas Fleet and was one of the most powerful figures in the imperial government of WILLIAM II. Entering the Prussian navy in 1865, he supervised the development of torpedoes for the German fleet in the 1870s and '80s. Later, as head of the Imperial Naval Office (from 1897) and grand admiral (from 1911), he skillfully built a battleship fleet second only to Britain's. Despite Tirpitz's efforts and his initially strong official and public backing, the German government decided to limit its buildup, which had succeeded in alienating the British and in coopting resources needed to maintain the strength of the army. The German navy was thus unprepared for World War I. Frustrated also in his support of unrestricted submarine warfare, Tirpitz resigned in 1916. Later, from 1924 to 1928, he represented an extreme right-wing party in the Reichstag.

Tirso de Molina [teer'-soh day moh-lee'-nah] Tirso de Molina was the pseudonym of the Spanish playwright Gabriel Téllez, b. Madrid, *c.*1584, d. 1648. Notable among his hundreds of plays is *The Love Rogue* (1630; Eng. trans., 1924), which created the character of Don Juan. A disciple of Lope de VEGA, Tirso de Molina also wrote Boccaccio-like stories, published in *Los Cigarrales de Toledo* (The Orchards of Toledo, 1621). He became a Mercedarian monk in 1601 and compiled (1637–39) a history of his order.

Tiryns [ty'-rinz] Late Bronze Age Tiryns—in the northeast corner of Greece's Peloponnesus near modern Argos—was a massive fortress whose great walls, like those of neighboring MYCENAE, were said to have been built by the legendary Cyclopes. The low hill on which the fortress stood had been occupied by an important settlement in the Early and the Middle Bronze Age, from *c.*2500 BC on. The first defenses were built *c.*1400 BC, but the fortifications were greatly strengthened about a century later. In the middle of the 13th century BC they were extended to include the lower part of the hill to the north. At the height of its prominence the town evidently bordered on the sea, although it is now some distance inland.

Tissaphernes [tis-uh-fur'-neez] Tissaphernes, d. 395 BC, was a Persian governor (satrap) and general in Anatolia. As governor of Lydia and Caria and general of the Achaemenid forces, he allied (413 BC) with Sparta against Athens during the PELOPONNESIAN WAR and recaptured most of IONIA. After CYRUS THE YOUNGER was made governor of Lydia and commander of the army in 407, however, Tissaphernes' command was limited to Caria. When Cyrus revolted against his brother ARTAXERXES II, Tissaphernes helped defeat Cyrus at the Battle of Cunaxa (401) and regained the governorship of Lydia. Defeated by the Spartans in 395 BC, he was assassinated by order of Artaxerxes.

tissue, animal Tissues are structured groupings of cells specialized to perform a common function necessary to the survival of the multicellular animal. The process of tissue formation (histogenesis) evolves from the earlier process of cell differentiation. The fertilized ovum divides to form the blastula, in which tissues are not yet defined. As growth continues, the cells of the blastula form the three germ layers—ectoderm, mesoderm, and endoderm. Cell differentiation begins the process of histogenesis and continues into the formation of organs. The cells in a tissue look more or less alike.

Epithelial tissue covers the surfaces of an animal and lines its tubes for digestion, respiration, circulation, reproduction, and excretion. This tissue controls what is absorbed into and lost from the organism. Outgrowths and ingrowths of epithelium form the sensitive surfaces of sensory organs, glands, hair and nails, and other structures.

The ability to contract and relax and thus provide movement is characteristic of muscle tissue. There are three types. Smooth muscle is activated by the autonomic nervous system. Skeletal muscle is controlled by the central nervous system and, to a certain extent, by the will. Cardiac muscle is characterized by its ability to contract rhythmically.

Nerve tissues consist of cells called neurons, which respond in a specific way to a variety of stimuli so as to transfer information from one part of the body to another.

Connective tissues support the body and connect its parts. Fibrous tissue is found in tendons and ligaments; elastic tissue in arterial walls, trachea, and ligaments between the vertebrae; and cartilaginous tissue in joints and in developmental bone stages. Adipose tissue cushions and supports vital organs and stores excess food.

Fluid tissues are the blood and lymph, whose functions include distributing food and oxygen, carrying waste products to the kidneys and lungs, and carrying defensive cells and other substances to destroy disease-producing agents.

tissue culture As a major advancement in biological research, tissue cultures have allowed investigators to maintain animal and plant cells or parts of an organ outside the donor's body. Cultured cells may grow by increasing in size and number, or they may either perform specialized functions or change into cells with special functions not present in the original cells. Normal mammalian cells in culture divide about once every 24 hours. Tissue-culture methodology has given researchers the opportunity to study specific cells and their interactions; to study cancer cells; to produce viral vaccines and hormones; to identify genetic defects; to classify malignant tumors; and to determine tissue compatibility in transplantation (tissue typing). Plant cells are also cultured to yield information on growth, metabolism, and cancers.

The cells are maintained in an incubating nutrient medium designed to closely approximate the serum or extracellular fluid of the donor—sap in the case of plants. Natural fluids or synthetic mixtures are used, or a combination of the two, called a semidefined medium. Some of the essential constituents of a medium are major ions, such as sodium; sugar, such as glucose for energy; enzymes; hormones; amino acids; respiratory gases; and water. The cells are usually grown as a single layer on a glass or plastic surface, unless they are suspended in a fluid medium under constant agitation. Sterile techniques and equipment are necessary, but antibiotics have reduced the need for absolute sterility. The cells are examined using light microscopy and other optical systems.

Tisza, István, Count [tis'-ah] A Hungarian statesman, Count István (Stephen) Tisza, b. Apr. 22, 1861, d. Oct. 31, 1918, entered the Hungarian parliament in 1886 and became leader of the Liberal party, prime minister (1903–05), and a champion of the Habsburg Dual Monarchy that guaranteed Hungarian domination of the eastern half of Austria-Hungary. Again prime minister (1913–17), Tisza reluctantly supported World War I but resigned when the new emperor, CHARLES I, sought to reform the franchise. Tisza was assassinated at the outbreak of the revolt for total Hungarian independence.

Titan (astronomy) [ty'-tuhn] Titan is the largest satellite of the planet SATURN. Among all the satellites of the solar system, it is second in size only to the planet Jupiter's Ganymede. Titan is also the only known satellite with a substantial atmosphere. The satellite was discovered in 1655 by Christiaan HUYGENS. It was observed most closely during the flyby of the VOYAGER *1* spacecraft in 1980.

Titan has a diameter of 5,140 km (3,194 m). It lies about 1,222,000 km (759,000 mi) from the center of Saturn, and takes nearly 16 days to orbit the planet. Its average density is 1.9 g/cm^3 (119 lb/ft^3), which indicates that it has a rocky core with a thick mantle of various ices, probably water, ammonia, and methane. The surface of the satellite is hidden by a thick atmosphere, about 1.6 times denser than the atmosphere of Earth. The cold atmosphere consists mostly of nitrogen, with about 6 percent methane, a trace of hydrogen, and possibly a small amount of argon.

The atmospheric pressure at the hidden surface is 16,320 kg/m^2 (23.2 lb/in^2), and the temperature there is about –180° C (–292° F). These conditions result in a poorly evolved, primitive atmosphere in which oxygen is missing, because it is frozen in the body of the satellite. Carbon-containing compounds are abundant, and the reddish color of Titan is perhaps due to organic molecules. No life forms could evolve at such low temperatures, however.

If methane is sufficiently abundant, it might exist at the surface in the form of lakes or even oceans of liquid methane. At the top of the atmosphere, radiation and particles from the Sun and elsewhere probably produce hydrogen ions that combine with carbon-containing molecules to produce organic compounds that condense and form haze layers. The particles gradually fall to the surface and, because of the low temperature, collect into a thick deposit.

Titan (rocket) Titan, the largest U.S. intercontinental ballistic missile (ICBM), is also used as a launcher (see ROCKETS AND MISSILES). The two-stage Titan II ICBM stands 31.4 m (103 ft) tall and has a diameter of 3.05 m (10 ft). The lift-off weight is about 149,690 kg (330,000 lb). Operationally, the single reentry vehicle usually carries a thermonuclear warhead of 5 to 10 megatons yield. The top range is 15,000 km (9,300 mi). Titan II has been in service since 1963, with 3 wings of 18 missiles each, stored in underground silos at Davis-Monthan AFB, Ariz.; McConnell AFB, Kans.; and Little Rock AFB, Ark.

Each of the two first-stage Titan II engines develops a thrust of 956,000 newtons (98,000 kg/215,000 lb). The single second–stage engine develops 445,000 newtons (45,500 kg/100,000 lb) of thrust. Modified Titan IIs were used in the GEMINI PROGRAM, and other modified Titans are used to launch Earth satellites and space probes. Heavy payloads are launched by the Titan IIID, consisting of two Titan core stages and two strap-on solid-propellant boosters. Titan 34D, used for unmanned military launches, is still more powerful; the explosion of a 34D in April 1986 caused severe damage to its launch pad. The Titan IIIC consists of a Titan II core, a restartable transstage with a thrust exceeding 70,000 newtons (7,257 kg/16,000 lb), and two strap-on boosters. The Titan IIIE, which launched two VIKING probes to Mars and two VOYAGER probes to Jupiter, Saturn, and Uranus, combined the technology of Titan IIIC with the high-performance CENTAUR stage.

Titanic [ty-tan'-ik] The *Titanic*, a British passenger liner, struck an iceberg off Newfoundland on the night of Apr. 14–15, 1912, and sank. The ship, the largest and most luxurious built up to that time, was on its maiden voyage from Southampton to New York, carrying more than 2,200 people; about 1,500 drowned.

Official inquiries determined that the *Titanic* was traveling too fast for the known icy conditions; it rammed the iceberg at a speed of 22 knots (41 km/h; 25 mph). The large loss of life was caused in part by the failure of a nearby ship, the *Californian*, to respond to the distress signals, and the insufficient number of lifeboats. The

In 1986, exploration of the Titanic *produced extraordinary photographs of the rust-festooned wreck, here being probed by the seeing-eye robot* J.J. *The robot is controlled through the yellow tether connecting it to the submersible research vessel* Alvin.

shipwreck, considered by contemporaries the worst in history, prompted international agreements to improve safety procedures at sea. The sunken vessel was located (1985) by a team of U.S. and French researchers.

titanium [ty-tay'-nee-uhm] Titanium is a silvery gray metal resembling polished steel. A transition element in Group IVB of the PERIODIC TABLE, its symbol is Ti, its atomic number is 22, and its atomic weight is 47.90. Titanium was first discovered as its oxygen compound in 1791 by William Gregor and named in 1795 by Martin H. Klaproth after the Titans of Greek mythology. The pure metal, obtained in 1910, remained a curiosity until an economical purification process was discovered in 1946.

Occurrence. Titanium is the ninth most abundant element, constituting about 0.63% of the Earth's crust. Rock samples from the Moon indicate titanium is far more abundant there. The most important titanium minerals are anatase, brookite, and rutile, all forms of titanium dioxide (TiO_2).

Uses. Because titanium is as strong as steel and 45% lighter, it is especially suitable for use in aviation and astronautics. About 50% of titanium production is used for jet-engine components. Titanium alloys readily with other metals such as aluminum and tin. The alloy composition Ti + 2.5% tin + 5% aluminum is used when high strength at high temperatures is required; and the alloy Ti + 8% aluminum + molybdenum + vanadium is used in applications at low temperatures.

Compounds. Few titanium compounds are used commercially. Titanium tetrachloride ($TiCl_4$), a colorless liquid that fumes in moist air, is used in the manufacture of artificial pearls and iridescent glass and, by the military, to create smokescreens. The most important titanium oxide is TiO_2, a white substance with a high reflective power. It is used extensively in paint, replacing the poisonous white lead. Titanium dioxide is processed at very high temperatures into artificial rutile, which is used as a semiprecious stone (titania). Titania has a light yellow color and a higher index of refraction than diamond but is rather soft.

Titans [ty'-tuhnz] In Greek mythology the Titans were the 12 offspring of URANUS (Heaven) and GAEA (Earth). In Hesiod's *Theogony* their names are given as Oceanus, the stream surrounding the world; Coius; Crius; Hyperion, sometimes regarded as a sun god; Iapetus, known as the father of Prometheus and Atlas in some myths; Thea, who was apparently associated with the sky; Rhea, who married CRONUS and mothered the original Olympian gods; Themis, sometimes listed as an earth goddess and an early wife of Zeus, who bore him the Hours and the Fates; MNEMOSYNE ("Memory"), mother, by Zeus, of the nine Muses; Phoebe, later identified with the moon; Tethys, sometimes associated with water; and Cronus, the most famous of the group, who castrated and killed his father and later led the Titans in their losing war against the Olympians. Several authors pictured the Titans in the section of the underworld called Tartarus, where they underwent lasting torment because of their sins against the gods.

tithe [tyth] A tithe is one-tenth of income or produce usually paid—whether levied as an official tax or offered as a voluntary contribution—to support a church and its charitable activities (although occasionally tithing has been used for secular purposes). Ancient peoples, such as early Hebrews, commonly levied tithes. Tithing was a common practice of the Roman Catholic church in western Europe beginning in the 6th century. About 200 years later it became compulsory by law in the Carolingian empire. Laws prescribing tithes were introduced in England during the 10th century. Tithing was abolished in France after the revolution of 1789. Some Protestant bodies consider the tithe mandatory.

Titian [tish'-uhn] Tiziano Vecellio, or Titian, b. *c.*1488, d. Aug. 27, 1576, was the greatest painter of the Renaissance in Venice and ranks as one of the most brilliant and influential masters in the entire development of European art. About 400 surviving paintings can be attributed to Titian with confidence, and many other now-lost works are known to have been produced during his extremely long and prolific career.

The tutelage of Giorgione in the early years of the 16th century gave the first great impetus to Titian's style. By the middle of the second decade of the 16th century Titian was painting such works as *Sacred and Profane Love* (*c.*1515, Galleria Borghese, Rome), which gives a full sense of the harmony and rich tonality of his sensuous classical style. His painting of the *Assumption* (completed 1518; Church of the Frari, Venice) displays the full extent of his powers in a work that is at once monumental in scale, intensely energetic, and vibrant in coloring.

Titian's personal development over an exceptionally long career was far ranging. The works of early maturity, such as *Bacchanal* and *The Worship of Venus* (both *c.*1519; Prado, Madrid), were succeeded in Titian's middle period (after *c.*1520) by a long series of exuberant, powerfully modeled compositions such as *Bacchus and*

Ariadne (1523; National Gallery, London), *The Entombment* (*c.*1525; Louvre, Paris), and *Venus of Urbino* (1538; Uffizi, Florence).

In 1533, Titian executed his second portrait of Holy Roman Emperor Charles V and was named court painter to the emperor; he was granted, along with his family, patents of nobility. Titian also became a favorite of, and executed many works for, Charles V's son, Philip II of Spain. In great demand for his portraits as well as for his altarpieces and classical subjects, Titian portrayed many of the most prominent European princes and sovereigns as well as notable personalities within his immediate circle. A rapid worker, he had the gift of penetrating the character of his sitters and was able to convey these insights, together with an air of dignity and an acute sense of physical vitality.

Titian, who had refused an invitation in 1513 to become painter to the papal court, traveled to Rome in 1545, where he was received as a great celebrity and made a citizen of the city. A work prompted by this visit is *Pope Paul III and his Grandsons, Cardinals Alessandro and Ottavio Farnese* (1546; Museo di Capodimonte, Naples).

His *Emperor Charles V on Horseback* (1548; Prado), one of his most distinguished works, became the prototype for equestrian portraits by later artists. The extremely rich effects of color, atmosphere, and light, always a remarkable feature of Titian's painting style, were even more pronounced in the works of his late period (after *c.*1545). In his control of rapidly applied and thickly brushed paint, Titian was capable of producing a tangible fusion of physical substance and light-filled atmosphere, as in *The Entombment* (1559; Prado), *Venus and Adonis* (*c.*1560; versions in Metropolitan Museum of Art, New York City, and National Gallery of Art, Washington, D.C.), and *The Rape of Europa* (1562; Gardner Museum, Boston). In his final works, *The Crown of Thorns* (*c.*1570; Bayerische Staatsgemaldesammlung, Munich) and *The Deposition* (1576; unfinished; Accademia, Venice), Titian became even more simplified and bold in his technique, endowing his works with an emotional impact that is mystical and haunting in its power.

For his Venus of Urbino *(1538) the Venetian master Titian chose an indoor setting, a richly furbished palace bedroom, instead of the conventional pastoral landscape used for mythological scenes. (Uffizi, Florence.)*

See also: ITALIAN ART AND ARCHITECTURE; PAINTING; RENAISSANCE ART AND ARCHITECTURE.

Titicaca, Lake [tee-tee-kah'-kah] Lake Titicaca lies in the Andes Mountains on the border of Bolivia and Peru at an altitude of 3,810 m (12,500 ft). It is the world's highest lake that can be navigated by large vessels. Covering an area of about 8,300 km^2 (3,200 mi^2), it is fed by more than 25 tributaries and drained by the small Río Desaguadero. A small southeastern basin called Uinamarca is linked with the northwestern part, Chucuito, by the narrow Strait of Tiquina. Chucuito has a maximum depth of about 280 m (920 ft), which keeps the waters at an annual average temperature of 11° C (51° F). This in turn moderates the local climate to allow cultivation of crops not usually grown at such high altitudes—corn, barley, quinoa, and potatoes. Settled since prehistoric times by AYMARA Indians, the shores of the lake remain densely populated.

Titius-Bode law [tee'-tee-us-boh'-de] The Titius-Bode "law," proposed (1766) by Johann Daniel Titius and popularized (1772) by Johann Elert Bode, was an attempt to explain the various mean distances of the planets from the Sun. The "law," which has never been explained by any physical argument, is expressed by the empirical formula $a = (n + 4)/10$, where a is the calculated mean distance expressed in astronomical units of a planet from the Sun and n is the progression of numbers 0, 3, 6, 12, 24, 48, 96, 192, and 384. The "law" approximates fairly well the mean distances of the planets (Mercury through Saturn) known at the time it was proposed and gives close values for the distances of Uranus, discovered in 1781, and some of the asteroids (between Mars and Jupiter), which began to be discovered in 1801. The distance of Neptune, however, does not fit within the "law."

title A title, as used in PROPERTY law, is the means by which an owner of property has just and legal possession of that property. Titles can be acquired through purchase or inheritance. Different types of title to one property can be held—for example, a MORTGAGE held by a bank on property owned by a person with a legal title to that property is an equitable title that expires on final payment. A DEED to a title is legal evidence of that title and thus of the holder's right to possess such property. The term *clear title* or *good title* means that the land is free of any or all encumbrances, such as an EASEMENT that could allow a neighbor the right to cross a property to reach a highway. A good title is one that the courts recognize as valid and thus free from doubts. Such a title is unflawed by LIENS (debt-claims) or by competing titles and ensures that the holder is the sole, legitimate possessor, without fear of any challenge being made to ownership.

See also: TORRENS SYSTEM.

titles of nobility and honor Titles of nobility and honor are the terms used to categorize those persons holding high rank in a nation socially organized along aristocratic lines. Modern European titles originated in feudal times, largely during the early Holy Roman Empire. Titles were formerly widespread, but today only a few nations recognize a formal peerage, Great Britain being the preeminent example. A provision of Article I, Section 9 of the U.S. Constitution prohibits the granting of titles of nobility by the United States.

Ruling Titles. In the traditional aristocratic society the monarch represents the apex of the hierarchy. The commonest titles of rulers are emperor (empress) and king (queen). Rulers of smaller nations often hold lesser titles: prince (princess), grand duke, or duke. Nonruling members of royal families also generally hold titles of nobility: prince or princess, duke or duchess, and sometimes lesser titles. In Britain, for example, the children of the sovereign are princes and princesses; the sons are often also created royal dukes. Prince Philip, the husband of Queen Elizabeth II, is also a royal duke: the duke of Edinburgh.

Duke. The duke (from the Latin *dux*, "leader") is the highest title in the peerage. The first nonruling duke was created in England by Edward III, who made his oldest son, Edward, the Black Prince, duke of Cornwall in 1337. The title, however, vanished altogether during the reign of Elizabeth I. Elizabeth's successor, James I, reinstated the title. Great victors in battle have been raised to dukedoms (for example, Marlborough and Wellington), but mostly the title went hand in hand with the great landholding magnates. Many of these were concentrated in mid-England, which became known as the Dukeries. No new nonroyal dukedoms have been created in the 20th century; the last created duke without royal connections was the duke of Westminster in 1874.

Marquess. This title dates from the Norman period. Originally the title applied to lords guarding the border areas, or marches. In Germany the comparable title was *Markgraf* (margrave), granted to counts who stood on border guard for the ruler; margraves could be further distinguished by the type of territory over which they ruled (*Landgraf* or *Pfalzgraf*).

Earl. The title of earl—third in precedence and the oldest title and rank of English nobles—is of Saxon-Danish origin (meaning "chieftain"). The earl was originally one who administered a shire or province. The equivalent Continental title is count (from the Latin *comes*, "companion"). In more recent times earldoms in Britain were conferred on retiring prime ministers but this practice has fallen into disuse, the last being Sir Anthony Eden, who became the earl of Avon in 1961.

Viscount. This title, which means vice-count, deputy, or lieutenant of a count, is an office that was well established in the Holy Roman Empire of Frederick I Barbarossa. Leading British soldiers of World War II (for example, Field Marshal Montgomery) were raised to the title of viscount.

Baron. Finally, the lowest on the ladder of peerage are the barons. They too came to England with the Norman invasion, and on the Continent barons remain the most numerous relics of a bygone age. The name meant an individual holding land directly from the sovereign.

Baronets and Knights. Members of these ranks are not members of the peerage; that is, they do not sit in the House of Lords. Baronets and KNIGHTS are both titled "Sir," but baronetcies are hereditary, and knighthoods are not. The term *baronet* was first applied to nobles who had lost the right of individual summons to Parliament in the 14th century. The hereditary order of baronets was introduced by King James I in 1611, and the title was sold to gentlemen prepared to establish plantations in Ireland. Nova Scotia was accorded a similar status for newly created baronets in 1624. The baronet is styled "Sir Thomas Beecham, Bart."

British knighthood has two forms: (1) the Knight (derived from the saxon *cnyt*, signifying "attendant") Bachelor and (2) the knight enrolled in one of the 8 orders of chivalry: the Order of the Garter—the oldest existing honor—for England, the Order of the Thistle for Scotland, the Order of the Bath, the Order of Saint Patrick, the Order of Saint Michael and Saint George, the Order of the Star of

EUROPEAN TITLES OF NOBILITY

British		*French*		*German*		*Italian*		*Spanish*	
Masculine	**Feminine**	**Masculine**	**Feminine**	**Masculine**	**Feminine**	**Masculine**	**Feminine**	**Masculine**	**Feminine**
duke	duchess	duc	duchesse	Herzog	Herzogin	duca	duchesa	duque	duquesa
*		prince	princesse	Fürst Prinz†	Fürstin Prinzessin	principe	principessa	principe	principea
marquess	marchioness	marquis	marquise	Markgraf Pfalzgraf Landgraf	Markgräfin Pfalzgräfin Landgräfin	marchese	marchesa	marqués	marquesa
earl	countess	comte	comtesse	Graf	Gräfin	conte	contessa	conde	condesa
viscount	viscountess	vicomte	vicomtesse			visconte	viscontessa	visconde	viscondesa
baron	baroness	baron	baronne	Baron Freiherr Freier	Baronin Freiherrin Freierin	barone	baronessa	barón	baronesa

* British prince or princess is a royal title, not one of nobility.
† Courtesy title for son/daughter of kings or dukes.

India, the Royal Victorian Order, and the Order of the British Empire.

French and German equivalents of the British knight are *chevaliers* and *ritters*. Both terms mean "horsemen," which indicates that the title was connected with mounted warriors and reflects the fact that from the days of the Roman Empire, mounted warriors enjoyed high social status.

Titles and Honors in the Modern Age. Active nobility has practically died out on the European continent with the extinction of the principal dynasties—Russian, French, Austrian, German, and Italian. Even in Britain, a considerable adaptation has been made. The creation of peers had always been a political act, and prime ministers have sometimes won their way by threatening to pack the House of Lords with newly created peers. The Life Peerages Act of 1958 allows nonhereditary barons and baronesses to be created. No new hereditary peers were created between 1964 and 1983, when the practice was revived. The Peerage Act of 1963 was passed to permit individuals to disclaim peerages and remain commoners—thus, for example, qualifying them to remain members of the House of Commons, where the real political power lies. The value of the modern honors system to Britain is that political or other services may be acknowledged by titles rather than by gold. Some observers see the system as a symbolic and inexpensive way of rewarding those who have performed some noteworthy service.

Almost all other nations have orders of honor, although the United States is extremely sparing and has just one, the Legion of Merit, which is for foreigners.

titmouse Titmouse is the common name for birds of the cosmopolitan family Paridae and, more specifically, for four small (12 to 15 cm/4.5 to 6 in) species of the genus *Parus* that are crested, mostly gray and white, and native to the United States and Mexico. In nonbreeding seasons titmice are gregarious, often joining the closely related chickadees and other winter birds in small, roving bands. The tufted titmouse, with a prominent crest and chestnut sides, is common in the eastern United States, the plain titmouse in the West, and the bridled titmouse in Mexico and the southwestern United States. Like chickadees, titmice tend to be tamed.

The bridled titmouse, a small, gregarious bird, is found in mountainous regions of the southwestern United States and northern Mexico.

Tito [tee'-toh] Marshal Tito (Josip Brož), b. May 25, 1892, d. May 4, 1980, became Yugoslavia's political leader in 1943 as president of the National Liberation Committee. In 1920, Tito joined the illegal Communist party in Croatia, acquiring the code name "Tito" when he became a member of the politburo in 1934. A recruiter (1936–38) for the International Brigade in Spain's Civil War, and an organizer of Yugoslavia's partisan forces after Germany's invasion during World War II, Tito led the highly effective Partisan Resistance Movement against Axis occupation of Yugoslavia. With the support of the USSR, the United States, and Great Britain, Tito officially became (1945) head of the new federal government. Although his regime was essentially a communist dictatorship, Tito's resistance to Soviet control led to a major split between himself and Stalin, and in 1948, Yugoslavia was expelled from the Soviet bloc. Tito then followed an independent course in foreign affairs—maintaining good relations with the East European socialist states, while establishing ties with the Western powers and nonaligned nations. Made marshal of Yugoslavia and elected president in 1953, Tito became president for life in 1974.

Marshal Tito, Yugoslavia's head of state from 1945 until his death in 1980, established a communist state notable for its economic decentralization, increased worker participation in government, and foreign policy of nonalignment.

Titograd [tee'-toh-grahd] Titograd (1987 est. pop., 82,500), the capital of Yugoslavia's republic of Montenegro, lies about 300 km (185 mi) southwest of Belgrade. The city manufactures tobacco, furniture, and food products. Only a few landmarks survived the World War II destruction, among them an 18th-century Turkish tower and a mosque. Known as Podgorica since the 1320s, the city was under the Turks from 1474 to 1878, and in 1921 it became part of Yugoslavia. It was renamed Titograd in 1946.

Titov, Gherman S. [tee-tawf'] The Soviet cosmonaut Gherman Stepanovich Titov, b. Sept. 11, 1935, was the second person to orbit the Earth. Titov was a Soviet Air Force jet pilot who was picked in the first group of cosmonauts in March 1960. He was backup pilot for the first manned spaceflight, *Vostok 1*, in April 1961, and on Aug. 6–7, 1961, he was pilot of the 25-hr 18-min *Vostok 2* flight. Apparent medical problems on the flight may have removed him from flight status, but in the early 1970s he was reported working as a test pilot on the Soviet Backfire long-range bomber program and as a specialist in long-range space communication.

titration [ty-tray'-shuhn] In chemistry a titration is a procedure for analyzing a sample solution by gradually adding another solution and measuring the minimum volume required to react with all of the analyte (constituent of interest) in the sample. The titrant (the solution that is added) contains a reagent whose concentration is accurately known (standard solution); it is added to the sample solution using a calibrated volumetric burette to measure accurately the volume delivered.

When a precisely sufficient volume of titrant has been added, the equivalence point, or endpoint, is reached. An endpoint can be located either visually, using a suitable chemical INDICATOR, or instrumentally, using an instrument to monitor some appropriate physical property of the solution, such as pH or optical absorbance, that changes during the titration. Ideally, the experimental endpoint coincides with the true equivalence point, where an exactly equivalent amount of the titrant has been added but in practice some discrepancy (titration error) exists. Proper choice of endpoint location system minimizes this error.

Once the concentration of an analyte in a solution is accurately known, the solution may be used as a titrant itself for other analyses. If the titration is part of a QUANTITATIVE CHEMICAL ANALYSIS, the data may be used to determine the composition of an unknown sample. Titrations can also be used to determine the number of acidic, basic, or other reactive groups of a compound. In such cases there may be more than one equivalence point. Titration data of acids and bases are used to determine dissociation constants (see CHEMICAL KINETICS AND EQUILIBRIUM) of molecules containing these groups.

Titus, Epistle to [ty'-tuhs] The Epistle to Titus, in the New Testament of the BIBLE, is one of the Pastoral Epistles (the others being the two Epistles to Timothy). It is addressed by Saint PAUL to his companion Titus, who has been left in charge in Crete to correct errors and appoint church leaders. Titus is urged to promote sound doctrine, sober behavior, and appropriate submission to those in authority. Many scholars think that the epistle was written in AD 100 in Paul's name rather than by Paul himself, because of differences in language, teaching, and church structure.

Titus, Roman Emperor Titus Flavius Vespasianus, b. Dec. 30, AD 39, d. Sept. 13, 81, spent most of his life in military service before succeeding (79) his father, VESPASIAN, as Roman emperor. In 70, Titus was entrusted with the command against the Jewish rebels. He captured Jerusalem and in 71 returned to Rome, where his father made him commander of the Praetorian guard. Later historians regarded Titus as an ideal emperor, in part because he spent great sums on games and monuments, including the COLOSSEUM. To the victims of the famous eruption (79) of Vesuvius and the plague and fire (80) in Rome he dispensed generous aid. The "era of good feeling" ended after his brother DOMITIAN succeeded him.

Tlaxcala Tlaxcala (meaning "rocky place" in Nahuatl), a state on the central plateau of Mexico, has an area of 3,914 km^2 (1,511 mi^2) and a population of 763,683 (1990). The capital is the city of Tlaxcala (1980 pop., 35,384). The smallest and most densely populated state in the country, Tlaxcala is primarily agricultural. The present Tlaxcala corresponds to the preconquest Tlaxcala kingdom, which was never subjugated by the Aztecs but was conquered by the Spanish under Hernán Cortés in 1519. Afterward, the Tlaxcalans became Cortés's allies and helped him destroy the Aztec empire.

Tlaxcalan [tlahs-kah-lahn'] The Tlaxcalan are Nahuatl-speaking Indians of North America descended from the Chichimec, who in preconquest times inhabited the Tlaxcala-Puebla region, an area roughly equivalent to the modern Mexican state of Tlaxcala. The Tlaxcalan population, estimated to number more than 500,000 in 1980, is distributed in 44 independent *municípios*, most of which are in rural areas. Living in what is probably the most ethnically and racially homogeneous area of the central Mexican highlands, the rural Tlaxcalan have maintained a strong identification with their cultural heritage. Their economy is based on cultivation, especially of maize, beans, and maguey. A key feature of Tlaxcalan social organization is a system of localized, patrilineal kinship units. The local religious government, barrio organization, and a folk religion containing a mesh of Christian and pagan beliefs have not succumbed to westernization.

Tlingit [tling'-git] The 13 Tlingit tribes are a group of North American Indians of the Nadene linguistic stock who formerly occupied the Alaskan Panhandle from Yakutat Bay southward. Their population numbered an estimated 10,000 in the mid-18th century but had dwindled to about 4,500 around the turn of the 19th century. Culturally adapted to rugged, forested coasts, they depended primarily on fish, sea mammals, mollusks, and berries for their subsistence. They built huge wooden dugout canoes, multifamily plank houses, and wooden storage boxes and dishes, made masks and woven spruce-root baskets, and twined robes of mountain-goat wool. Matrilineal exogamous moieties (complementary divisions) functioned on socioceremonial occasions, such as those celebrating life crises, house building, memorial rites, or POTLATCHES—ceremonial feasts involving property distribution.

Conflict between the Russians and the Tlingit was frequent. In 1802 the Tlingit drove the Russians from a fort on an island in the southeast archipelago, but Russian trader Aleksandr Andreyevich BARANOV recaptured the fort and turned it into a trading post, which grew into the present-day city of Sitka. The Tlingit (and the Haida) in southeastern Alaska numbered about 18,600 in 1991.

TMJ syndrome Temporomandibular joint (TMJ) syndrome, also known as myofacial pain dysfunction, is a disorder in the joint between the mandible (lower jawbone) and the temporal bone of the skull. Symptoms include blurred vision, sinus problems, and pain in the jaw, head, neck, shoulders, and ears. Possible causes are arthritis, malocclusion (bad bite), bruxism (grinding or clenching of teeth), muscle tension, and psychological stress. Treatment ranges from jaw exercises and drug therapy to dental procedures and surgery. It is estimated that nearly 25 percent of the U.S. population suffers from some form of TMJ syndrome, although most cases are not treated.

TNT see EXPLOSIVES

To Kill a Mockingbird *To Kill a Mockingbird* (1960; film, 1962), Harper Lee's first novel, won the Pulitzer Prize for fiction. Set in a small Alabama town and narrated by a young girl, Scout Finch, the novel relates the impact of a rape trial on the community. A young black man, accused of rape, is defended by Scout's father, a lawyer. Although the narrator's angle of vision is limited, it becomes clear that the trial has aroused all the latent tensions of the community.

To the Lighthouse *To the Lighthouse* (1927), regarded as one of Virginia WOOLF's finest novels, uses a carefully patterned STREAM OF CONSCIOUSNESS technique that attempts to echo the scattered conversations and random thoughts that occur in the minds of several of the characters. Usually the narrators are observing Mr. and Mrs. Ramsay, an upper-middle-class British couple on vacation with a houseful of children and guests. Mrs. Ramsay, the heart of the group, devotes her life completely to her family—a fact realized by them only after her death.

The American toad burrows about 1 m (3 ft) deep in loose soil in the fall and hibernates until spring.

toad Toads are rough-skinned, generally land-dwelling, tailless amphibians closely related to frogs. True toads make up the family Bufonidae. More than 200 species, classified in the genus *Bufo*, are found in North and South America, Europe, Asia, and Africa from sea level to more than 4,500 m (15,000 ft) in the Himalayas. Members of other genera are also found throughout the world except in Australia and Antarctica—some only in tropical areas.

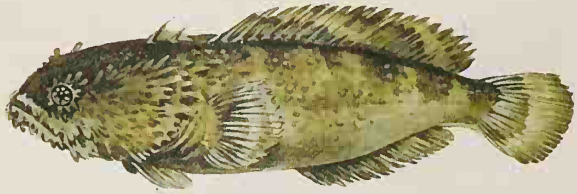
The name *toad* is also used to refer to certain frogs. These include the Mexican burrowing toad, *Rhinophrynus dorsalis*, family Rhinophrynidae; the Surinam toads, genus *Pipa*, family Pipidae; the fire-bellied toads, *Bombina*, and the midwife toad, *Alytes obstetricans*, family Discoglossidae; and the spadefoot toads, *Scaphiopus*, family Pelobatidae.

Toads generally have squat bodies and short legs. Most are moderate-sized, about 5 to 8 cm (2 to 3 in) long; some, however, such as the oak toad, *Bufo quercus*, may be only 20 to 30 mm (0.8 to 1.2 in); others, such as Blomberg's toad, *B. blombergi*, may reach 150 mm (6 in) or more. Most are drab. A few genera of toads are brightly colored or spotted. Malaysian tree toads, *Pedostibes*, for example, are green with yellow and blue spots, and male Costa Rican toads, *B. periglenes*, are bright gold.

A toad's thick, warty skin allows it to inhabit drier regions than does a frog. Toads are found in fields, gardens, woodlands, and meadows as well as moister areas. They frequently use horny projections on their hind feet to dig shallow burrows in which to hide. As cold weather approaches, they find a secluded spot and hibernate. Toads do not jump as frogs do, but make short hops or even walk. They are carnivorous, feeding mostly on insects. Toads are the prey of many animals. When provoked or injured, toads secrete a poison from their skin. In most species poison glands are scattered over the body, but they may be concentrated on the side of the neck. Toads also defend themselves by inflating their bodies, a tactic that increases their bulk and makes them harder to swallow.

Toads typically breed in water. They are very prolific, most laying 20,000 eggs in a single clutch, with the giant toad producing as many as 100,000 eggs at a time. The eggs hatch into tailed aquatic larvae (tadpoles) that metamorphose into the adult form in a few weeks. Several toads depart from this mode of reproduction. Some species lay eggs on land and lack a free-swimming tadpole stage; in others fertilization is internal, and birth is given to fully formed toadlets.

toadfish The toadfish is a wide-bodied, usually drab-colored, often pugnacious fish found mostly in warm



The oyster toadfish, a carnivorous fish whose name is derived from its warty skin, lives in coastal waters of the western Atlantic.

coastal regions. The more than 30 species constitute the family Batrachoididae. Toadfish are usually less than 38 cm (15 in) long, are often slime-covered, and have a large head with upward-directed eyes and a large mouth. Some species (genus *Thalassophryne*) have venom glands attached to fanglike dorsal-fin spines. Other species (genus *Porichthys*), often known as midshipmen, have light organs on the belly. Mostly bottom dwelling and slow moving, toadfish feed on crustaceans, mollusks, and small fish. One common species in the western Atlantic is the oyster toadfish, *Opsanus*. When caught by an angler, it often grunts, erects spines, and may inflict a painful wound.

toadflax Toadflax comprise 100 species of plants in the genus *Linaria* of the family Scrophulariaceae. These annual or perennial herbs are widely distributed in the temperate Northern Hemisphere, mainly in the Mediterranean region. The common toadflax, *L. vulgaris*, is a vigorous perennial often regarded as a weed.

Common toadflax, a flaxlike weed, has flowers the color of butter and egg yolks, giving the plant its common name, butter-and-eggs.

toadstool *Toadstool* is a common term for fleshy and umbrella-shaped poisonous fungi. MUSHROOM is the term usually applied to edible species of fungi. Scientists who study fungi, however, make no such distinction between toadstools and mushrooms. Many of the poisonous types belong to the genus *Amanita*. Some species in this genus have a volva, or cup, often nearly hidden in the ground, into which the stem usually fits. This cup, termed the *death cup*, can be present or absent in either edible or poisonous mushrooms of the genus. Therefore, the specific species must be identified using other characteristics. The commonly encountered poisonous fungi include the death cup, *A. phalloides*; the destroying angel, *A. verna*; and the fly amanita, *A. muscaria*.

tobacco Tobacco is a tall, herbaceous plant, the leaves of which are harvested, cured, and rolled into cigars, shredded for use in cigarettes and pipes, and processed for chewing or snuff. Tobacco is an important crop in most tropical countries and in many temperate ones. The main source of commercial tobacco is *N. tabacum*, although *N. rustica* is also grown and is used in Oriental tobaccos. Growers have developed a wide range of varieties, from the small-leaved aromatic tobaccos to the large, broad-leaved cigar tobaccos.

History

Tobacco is native to the Americas, and the practice of inhaling the smoke of the dried plant material has been documented in the Mayan culture more than 2,000 years ago. The Mayans moved northward from Central America through the Aztec Empire and eventually took their customs to North American Indian tribes. The Arawak Indians of the Caribbean smoked tobacco; Christopher Columbus, during his 1492 voyage, found them smoking loosely rolled cigars. The Spanish took tobacco seeds to Europe, where Jean Nicot gave the plant its generic name, *Nicotiana*. Sir Walter Raleigh began the popularization of pipe smoking in Great Britain in 1586, and the cultivation and consumption of tobacco spread with each voyage of discovery from Europe.

Two kinds of tobacco were traded between Europe and America: Spanish, from the West Indies and South America, and Virginia, from what is now the state of Virginia. The Spaniards were the first Europeans to cultivate substantial amounts of tobacco. Despite its popularity in England, James I—who vehemently disapproved of tobacco—forbade its production there. Europeans at first smoked their tobacco in PIPES, and later in cigars. Cigarettes grew in popularity only after the Crimean War (1854–56); their spread was aided by the development in the United States of the first cigarette-making machine in 1881 (see DUKE, JAMES BUCHANAN).

Cultivation

Unlike most other annual agricultural crops, tobacco has a small seed (1 oz = 300,000 seeds), which cannot be sown directly in the field. Seedlings are raised in carefully selected and tended seedbeds where protection is given against heavy rain and excess sun. Young seedlings are planted out by hand or by mechanical transplanter. The crop needs a minimum of 120 frost-free days and can be grown in a variety of soils.

Producing disease-resistant tobacco of acceptable quality is difficult, because the plant is susceptible to many diseases. Chemical control is now widely practiced, although the choice of chemicals is limited by the need to ensure that they do not taint the tobacco when it is smoked.

In the United States and Canada, tobacco is often stalk-cut by machine, but in many parts of the world, it is still harvested leaf by leaf. Only a fully ripe leaf is used. After harvesting, leaves are tied together in pairs on curing sticks or strings.

Curing

Four different methods are used to cure, or dry, tobacco. Flue curing, used mainly in the manufacture of cigarettes, produces a tobacco with a high sugar content and a medium to high nicotine content. It requires a closed building equipped with a ventilation system and a heat source.

Air-cured tobaccos, such as cigar tobaccos and burley tobaccos, have a low sugar content but vary in nicotine content. Air curing requires an open framework in which leaves (or whole plants) are hung, protected from wind and sun.

Fire-cured tobacco is used mostly for pipe-tobacco mixtures, snuff, and chewing tobacco. It has a low sugar but high nicotine content. Fire curing employs an enclosed barn. Small fires are built on the floor, and the leaves cure in a smoke-laden atmosphere.

Sun curing is the drying of leaves in the sun. These tobaccos are used in cigarettes and have characteristic aromas. They are low in both sugar and nicotine.

Grading and Aging

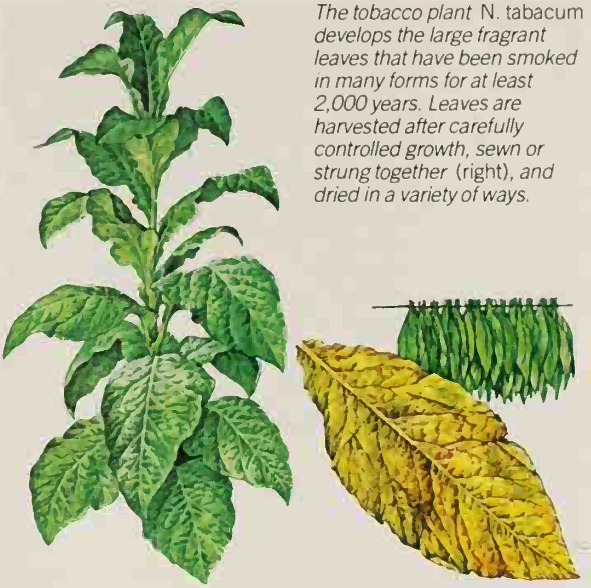
After curing, the moisture content is standardized (the process is called redrying) to maintain the characteristics of the tobacco for the 12 to 18 months it is held prior to being used. (Oriental tobaccos are not redried; instead they are stored in small bales and allowed to ferment.) After storage, moisture is added and the tobacco is blended to achieve the differing qualities needed for cigarettes, cigars, pipe tobaccos, snuff, or chewing tobacco.

In the mid 1980s the leading tobacco producers were China, the United States, India, Brazil, the USSR, and Turkey.

The U.S. Tobacco Industry

Some 180,000 farms in six southern states grow tobacco, often as the only crop. In many hundreds of small towns, it provides the farmer with the sole source of cash to buy equipment and supplies from local merchants. The U.S. Department of Agriculture includes tobacco in its price-support system, both because of its economic significance to the South and because, for many years, it has been an important export crop. American tobacco companies also play a major part in the U.S. economy, earning millions on domestic sales and on exports to Third World countries, especially in Asia.

Fears of the health effects of long-term use of tobacco (see nicotine and smoking) have cut per capita cigarette consumption in the United States. In addition, the U.S. share of the world tobacco market has fallen, and imports of low-cost tobaccos have cut into domestic tobacco sales.



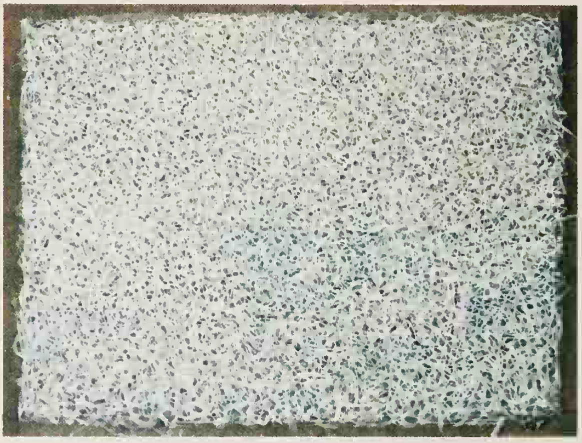
The tobacco plant N. tabacum *develops the large fragrant leaves that have been smoked in many forms for at least 2,000 years. Leaves are harvested after carefully controlled growth, sewn or strung together* (right), *and dried in a variety of ways.*

The cigarette industry continues to deny that there is a direct connection between the ingestion of tobacco smoke and the development of respiratory diseases. Despite antismoking campaigns and health warnings on cigarette packets, there are about 50 million U.S. smokers. Tobacco products such as snuff and chewing tobacco attract the young; the Federal Trade Commission requires warnings on packages of these products, indicating that they are not safe alternatives to cigarettes and may cause mouth cancer and gum disease.

Tobacco Road *Tobacco Road* (1932), a novel by Erskine Caldwell, deals half-humorously, half-seriously, with an amoral family of Georgia sharecroppers. Living in a rickety cabin are Jeeter Lester, the impoverished patriarch, his mother, wife, children, and assorted relatives. They marry at very young ages and play a slightly mad game of sexual musical chairs until Jeeter and his wife perish in a fire. Jack Kirkland dramatized the novel in 1933, and the play ran for more than 3,000 performances. John Ford directed the film version (1941).

Tobago see Trinidad and Tobago

Tobey, Mark [toh'-bee] Mark Tobey, b. Centerville, Wis., Dec. 11, 1890, d. Apr. 24, 1976, was more than 40 years old when he developed the unique calligraphic painting style for which he is known. He viewed this "white writing," characterized by meshed, light lines set against a darker background, as a means of evoking the



Mark Tobey's Microcosmos *(1959), painted in what the artist called "white writing," suggests a self-contained web of tense energy. (Private collection.)*

chaotic energy of cities and of humanity itself. The Oriental affinities of Tobey's art are often cited, and both Chinese and Japanese art clearly influenced his linear expression. It was his Baha'i faith, however, which stresses the oneness of humankind, that gave Tobey's lines their symbolic meaning. His evocative spirituality is exemplified by *Early Light* (1970; collection of the artist's estate, Basel, Switzerland).

Tobit, Book of [toh'-bit] Tobit, or Tobias, is a book in the Old Testament Apocrypha, written (*c.*200–170 BC) in Hebrew or Aramaic and constructed as a didactic romance. It became popular among Hellenistic Jews and Christians in its Greek translation. The book relates how Tobit, a devout Jew in exile in Assyria, and his son Tobias were rewarded for their piety and good deeds. Tobit buried the bodies of executed Jews in Nineveh. Despite this and other good works, he was blinded. As he prays for God to end his life, Sarah, a widow whose seven husbands have each been killed by the demon Asmodeus on their wedding night, also entreats God to end her misery. In answer to these prayers, God sends the angel Raphael to Earth to help them. Tobias marries Sarah and, with Raphael's help, overcomes the demon and restores his father's sight.

tobogganing Tobogganing is a winter sport in which a runnerless sled is used to slide down an incline or course of snow or ice. It is primarily a recreational sport.

American Indians built the first toboggans about 5,000 years ago to transport goods over long distances in the snow. Tobogganing developed as a sport in the 1880s among Americans and Englishmen vacationing at Saint Moritz, Switzerland, and thrived until the 1930s ascent of skiing.

Originally, the Indians made their toboggans out of animal skins stretched tightly over wooden frames. A modern toboggan is made of several long, thin boards curled up and backward in front to form a prow.

In Europe the various kinds of sledding, especially Cresta racing and luging (see LUGE), are also called tobogganing. Sledding, a form of transportation also of ancient origin, developed as a sport in 19th-century mountain resorts. Cresta tobogganing, in which the rider lies down on a "skeleton," a light wooden body with steel runners, has been practiced for more than a century on the treacherous 1,212-m-long (1,325-yd) run in the Cresta Valley at Saint Moritz.

Tobruk [toh-bruk'] Tobruk is a port city in northeastern Libya on the Mediterranean Sea with a population of 75,282 (1984). Food processing is the major industry. The principal export is petroleum, transported by pipeline from the Sarir oil field 515 km (320 mi) to the south. Originally a Greek agricultural colony, Tobruk later became a Roman fortress and an important city on the caravan routes. The Italians occupied it in 1911 and used it as a military base. During World War II, Tobruk was taken by the Allies in 1941, lost to the Germans in June 1942, and retaken by the British within a few months.

toccata [tuh-kah'-tuh] The term *toccata* (derived from the Italian *toccare*, "to touch") is a title for keyboard pieces in free style—generally with much elaborate passage work in rapid tempo—that exhibit the player's touch, or dexterity. The term's significance is imprecise, however, when applied to such works as the harpsichord toccatas of J. S. Bach, which are divided into several contrasting movements. Rhapsodic and virtuoso elements are generally characteristic of the genre.

As it originated in the 16th century, the toccata consisted of alternating chordal and scale passages, but by the end of the century fugal passages also had been introduced. The toccata tended to become a brilliant showpiece, but examples for the organ by Giralomo Frescobaldi are in a restrained style and were sometimes performed during Mass. The genre was further developed by such 17th-century organists as Dietrich Buxtehude, Johann Pachelbel, and Jan Sweelinck, culminating in the great toccatas and fugues for organ by Bach. The toccatas of later composers—Robert Schumann and Sergei Prokofiev, for example—are usually in a fast tempo with the same figuration and continuous rhythm throughout.

Tocqueville, Alexis de [tohk-veel'] Alexis de Tocqueville, b. July 19, 1805, d. Apr. 16, 1859, was a French politician and writer best known for his classic study of the United States, *Democracy in America* (2 vols., 1835, 1840; Eng. trans., 2 vols., 1835–40). A member of an aristocratic family, Tocqueville joined the government service as a lawyer and went (1831) to the United States to study the American penal system. Profoundly affected by his experience, he returned (1832) to France and while serving in the Chamber of Deputies completed *Democracy in America*. In 1849, Tocqueville served as minister of foreign affairs. He later wrote *The Old Regime and the French Revolution* (1856; Eng. trans., 1856), an introductory volume to a planned history of the French Revolution. In *Democracy in America*, Tocqueville affirmed his commitment to human freedoms and helped establish the European view of the United States as a land of liberty, equality, and political wisdom. Tocqueville felt that the old aristocratic institutions of Europe would inevitably give way to democracy and social equality, and he held up the American system as a successful model. Tocqueville's praise for the young country's ideals was not unqualified, however. He felt that democracy was an inevitable political force; at the same time, however, he feared that virtues he valued—freedom, civic participation, taste, creativity—would be imperiled by "the tyranny of the majority," individualism, and other democratic despotisms.

Togliatti [toh-lee-aht'-tee] A major center of the Soviet automobile and chemicals industries, Togliatti (1989 pop., 630,000) is located in the Russian republic on the Volga River about 100 km (60 mi) upstream from Kuibyshev near the Kuibyshev Dam. Once known as Stavropol, the small town was transplanted from the river's banks following the dam's construction in the 1950s and renamed in honor of the Italian Communist leader Palmiro Togliatti when a Fiat car plant was built there in 1964.

Togliatti, Palmiro Palmiro Togliatti, b. Mar. 26, 1893, d. Aug. 21, 1964, led the Italian Communist party from 1926. Jailed (1925) by the Fascist regime of Benito Mussolini, Togliatti was released under a general amnesty. In exile from 1926, he became party leader and worked principally from Paris. He served as chief of Comintern operations in Spain during the Spanish Civil War (1936–39) and spent most of World War II in the USSR. After the war Togliatti molded Italy's Communists into one of Western Europe's strongest Communist parties and increasingly advocated the independence of national Communist parties from the Soviet party line. A Soviet city (Stavropol) was renamed for him in 1964.

Togo [toh'-goh] The Republic of Togo is located on the Gulf of Guinea in western Africa immediately north of the equator. It is a long, narrow country, lying between Benin on the east and Ghana on the west, with Burkina Faso bordering the north. Once a German colony, Togo gained

AT A GLANCE

TOGOLESE REPUBLIC

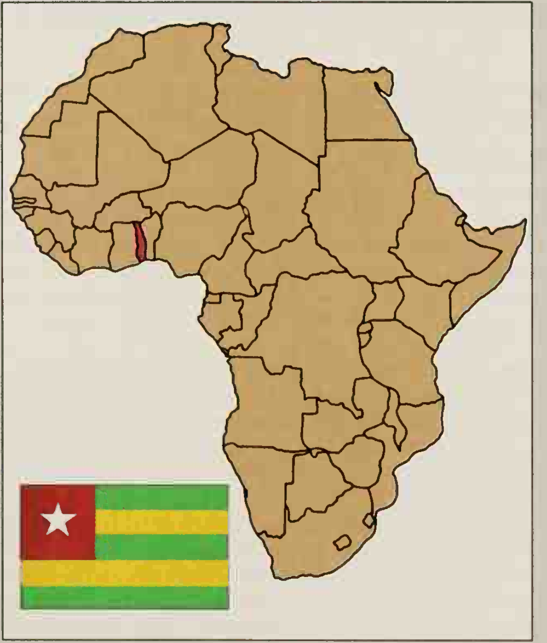
Land: Area: 56,785 km^2 (21,925 mi^2). Capital and largest city: Lomé (1983 est. pop., 366,476).

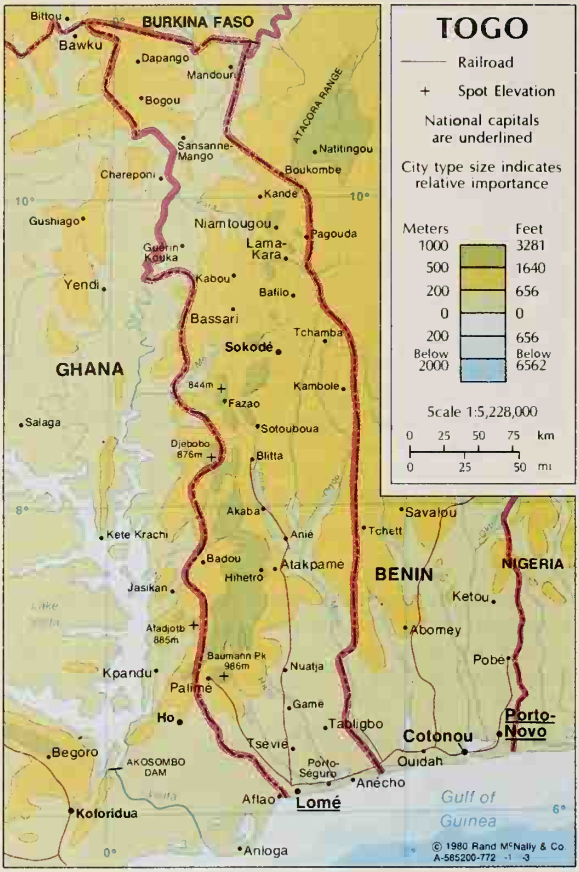
People: Population (1990 est.): 3,674,355. Density: 64.7 persons per km^2 (167.6 per mi^2). Distribution (1987): 24% urban, 76% rural. Official language: French. Major religions: traditional religions, Christianity, Islam.

Government: Type: one-party state. Legislature: National Assembly. Political subdivisions: 5 regions.

Economy: GNP (1988 est.): $1.35 billion; $405 per capita. Labor distribution (1985): agriculture—71%; other—29%. Foreign trade (1988): imports—$369 million; exports—$344 million. Currency: 1 C.F.A. franc = 100 centimes.

Education and Health: Literacy (1985): 41% of adult population. Universities (1987): 1. Hospital beds (1982): 3,655. Physicians (1985): 230. Life expectancy (1990): women—57; men—53. Infant mortality (1990): 112 per 1,000 live births.





its independence from a French-administered United Nations trusteeship in 1960.

Land and Resources

Beyond the narrow coastal plain lies an ancient plateau, 60–460 m (200–1,500 ft) in elevation, which covers more than half of the country. A small mountain chain interrupts the plateau, with the highest elevation at Pic Baumann (986 m/3,235 ft). In the north the plateau gives way to the alluvial plain of the Oti River. To the east is the Plain of Mono.

The south has a rainy season during October and November. Rainfall averages 711 mm (28 in) per year in the south and 1,600 mm (63 in) per year in the plateau region. In the north about 1,143 mm (45 in) of rain falls between April and July. Temperatures throughout Togo average about 26° C (78° F).

The southern half of the country is drained by the Mono River and its tributaries, while the north is drained by the Oti, an affluent of the VOLTA River. Along the sandy coastline is a fringe of cocoa palms and mangroves, whereas savanna covers most areas of the interior. Togo has deposits of iron ore in the north and phosphates in the southeast.

People

Togo has 37 ethnic groups. In the south, the largest groups are the EWE and the Mina; in the north, the chief ethnic group is the Cabrais. French is the official language, and Ewe is the lingua franca of half the population. Dagomba and Kabie are also widely spoken in the north, although the many Hamitic peoples speak a multitude of different languages. The population is about 37% Christian and 18% Muslim. The remaining inhabitants practice traditional African religions. LOMÉ, the capital, is the largest town and chief port.

Six years of primary education is compulsory, but only about two-thirds of all children attend primary school and only about one-fifth continue on to secondary school. The university at Lomé was founded in 1965. Health services are poor.

Economic Activity

Agriculture, primarily at the subsistence level, dominates the economy. Yams, cassava, corn, beans, rice, millet, and sorghum are grown for food; coffee, cacao, and cotton are the main cash crops. The country has been generally self-sufficient in food since 1982. Fish provide an important source of protein, and livestock is raised.

Phosphates, the chief source of foreign exchange, comprise about 50% of exports. Cotton-ginning, food-processing, and handicrafts industries generally produce for the domestic market. Togo is burdened by a large foreign debt.

History and Government

The Ewe and related peoples moved into what is now Togo from the east between the 12th and 18th centuries. The area was part of the German colony of TOGOLAND (1884–1914). It was then administered by France as a League of Nations mandate and later as a United Nations trust territory until it gained independence on Apr. 27, 1960. Sylvanus Olympio, the first president of independent Togo, was assassinated in a 1963 coup. His successor, Nicolas Grunitzy, fled after a coup in January 1967 and was replaced by Gnassingbe Eyadema, the head of the armed forces. Eyadema appointed a civilian cabinet and established (1969) the Togolese People's Assembly, the sole political party. In 1979 voters approved a new constitution creating a directly elected legislature. Eyadema, reelected in 1979 and 1986, has survived several coup attempts. Late in 1990, after demonstrations demanding political reform, a constitutional commission was appointed as part of a proposed transition to a multiparty system. A constitutional referendum was to be held in December 1991.

Togo Heihachiro [toh'-goh hay-hah'-chee-roh] The Japanese admiral Togo Heihachiro, b. 1846, d. May 30, 1934, was a hero in the RUSSO-JAPANESE WAR (1904–05). After studying naval science in England, he served with distinction in the Sino-Japanese War (1894–95). As Japanese naval commander, Togo attacked Port Arthur in

1904, and in 1905 he won a decisive victory at the Battle of TSUSHIMA.

Togoland The German colony of Togoland, in West Africa, was founded in 1884. After World War I it was made a League of Nations mandate, with the western half under British administration and the eastern half administered by France. In 1948 it became a United Nations trust territory. British Togoland chose (1956) to merge with the Gold Coast (now Ghana); the French zone became the independent nation of Togo in 1960.

Tohaku [toh-hah'-koo] The Japanese painter Hasegawa Tohaku, 1539–1610, was the only artist of the Momoyama period to compete successfully with Kano EITOKU for the patronage of the shogun Hideyoshi. His work is greatly influenced by that of the Chinese painter Mu-ch'i. In his masterpiece, the set of screens titled *Pines in Mist* (National Museum, Tokyo), he combined Mu-ch'i's ink-wash technique with the lyric mood of a Japanese scene.

toilet The toilet, or water closet, is a bathroom fixture for the disposal of human waste, using a bowl that can be flushed with water. Latrines were sometimes water-flushed in ancient times and the Middle Ages, utilizing either diverted streams or buckets. The modern water closet, pioneered (1775) by London watchmaker Alexander Cumming and improved (1778) by inventor Joseph Bramah, originally consisted of a cast-iron bowl with a flap valve (a hinged valve permitting flow in only one direction); the bowl emptied directly into the drains. Later a trap—a curved section of pipe that contained standing water—was added to prevent sewer gas from entering the house. In the mid-19th century, ceramic toilet bowls were introduced for easier cleaning, and traps were made more effective by venting. In 1890 the modern "washdown closet" form was developed; the elevated water-tank was lowered to its present position about 1915. Public toilets have long used flush valves rather than tanks.

Tojo Hideki [toh'-joh hee-day'-kee] Tojo Hideki, b. Dec. 30, 1884, d. Dec. 23, 1948, prime minister (1941–44) of Japan during World War II, was a leading advocate of Japanese military conquest. After graduating (*c.*1915) from the Military Staff College, he gained rank steadily and by 1937 was commander in Manchuria.

Japan's prime minister KONOE FUMINARO made Tojo minister of war in 1940. After becoming prime minister as well in October 1941, Tojo approved the attack against the United States at Pearl Harbor. His initial successes against the United States and in Southeast Asia made him highly respected, but with Allied forces on the offensive, Tojo was forced to resign in July 1944. Arrested in 1945 as a war criminal, he was found guilty by the International Military Tribunal and was hanged.

tokamak The tokamak is one of the more promising devices intended to release nuclear FUSION ENERGY. By means of strong magnetic fields it can contain a plasma consisting of electrically charged particles at high temperature. In such a plasma the fusion of nuclei of hydrogen isotopes (deuterium and tritium) provides great quantities of heat energy, which can be converted into useful electrical energy. At present, however, more energy is required to achieve fusion than is released.

The tokamak design, conceived by Soviet scientists Andrei SAKHAROV and Igor Tamm, began to draw interest in the early 1960s. (The word *tokamak* is an acronym for Russian words meaning "toroidal magnetic chamber.") Tokamaks also have been and are being built in the United States, Japan, the United Kingdom, and some nations of Western Europe.

The main components of a tokamak are (1) a doughnut-shaped vacuum chamber (torus) in which the plasma is produced; (2) current-carrying, superconducting magnetic coils wrapped around the torus to produce a magnetic field that restrains charges from moving outward (magnetic confinement); (3) additional coils to produce a changing magnetic field that induces a current in the plasma and thus provides ohmic heating toward the temperature—50 million K—at which nuclear fusion occurs (these currents along the axis of the torus produce another field that helps confine the plasma); and (4) a "blanket" material, such as liquid lithium, surrounding the plasma to take up the energy of neutrons produced in the fusion reaction, to capture slow neutrons to produce fresh tritium fuel, and to provide protective shielding for the magnet coils.

The goal of tokamak research is to reach the "break-even" condition, in which as much fusion energy is released as is supplied externally to the tokamak. Fusion scientists are trying to achieve this at various large projects. These include the Tokamak Fusion Test Reactor (TFTR) at Princeton, put into operation in 1982; the Joint European Torus (JET), constructed in England by the European Economic Commission and put into operation in 1983; the Japanese Tokamak (JT-60) in Japan, which began operating in 1985; and the Soviet Union's T-15 and France's Tore-Supra, which both started up in the late 1980s.

Tokelau [tohk-uh-low'] Tokelau, a non-self-governing territory of New Zealand, is made up of three atolls—Atafu, Fakaofo, and Nukunono—located in Polynesia in the south central Pacific Ocean. Although each atoll has its own center for administering village affairs, Tokelau's official administrative base is in Apia, Western Samoa. The territory's total land area is about 10 km^2 (4 mi^2); the population, mostly Polynesian, is 1,700 (1990 est.). Agriculture and fishing are the economic mainstays; coconuts are the only cash crop.

British explorer John Byron discovered the islands in 1765. Britain annexed them in 1877 and made the Tokelaus (then known as the Union Islands) part of the crown colony of the Gilbert and Ellice Islands (see KIRIBATI; TUVALU) in 1916. Assigned to New Zealand in 1925, they became a territory of that country in 1948.

Tokugawa (family) [toh-koo-gah'-wah] The Tokugawa house, founded by Tokugawa IEYASU, dominated Japanese politics from 1603 to 1867 (the Tokugawa period). Ieyasu emerged from the Battle of Sekigahara (1600) as the most powerful military leader in Japan. Appointed shogun by the emperor in 1603, he established the capital at his castle town of Edo (Tokyo). His political system made the shogun the national authority and the daimyo (lords) the local rulers. **Hidetada** (1579–1632; r. 1605–23) succeeded his father as shogun, while Ieyasu retired to consolidate Tokugawa power. The third shogun, **Iemitsu** (1604–51; r. 1623–51), barred trade with the West and suppressed Christianity.

The Tokugawa monopolized foreign trade, mining, and the major cities of Edo, Kyoto, Osaka, and Nagasaki. Only vassals of the ruling house were appointed to powerful positions; the clergy and nobility were placed under Tokugawa control, as was the emperor. All the daimyo had to reside at Edo for part of the year, and when elsewhere, they left family members at Edo as hostages. The Tokugawa controlled one-fourth of the rice lands, certified daimyo succession and land titles, and regulated the actions of their vassals. **Yoshinobu** (or Keiki; 1827–1913, r. 1866–67), the 15th and last Tokugawa, was overthrown amid rising dissatisfaction over the dynasty's inability to prevent Western penetration. The subsequent MEIJI RESTORATION marked the emergence of modern Japan.

Tokyo Tokyo is the capital and most important city of Japan. Lying at the southeastern elbow of Honshu, the largest Japanese island, it is one of the world's leading financial and commercial centers. The Tokyo prefecture, made up of 23 central wards, 2 counties, and several islands south of Tokyo Bay, has a population of 11,885,000 (1989 est.), nearly 10% of the population of all Japan. The inner wards, which made up the original city, have a population of 8,278,116 (1989 est.). From Tokyo, at the head of Tokyo Bay, through Kawasaki and Yokohama, on the western shore, extends a conurbation within which nearly 30 million people live.

Contemporary City. Twice during the 20th century Tokyo was nearly destroyed, once after the tragic earthquake and fire of 1923 and a second time after the incendiary-bomb air raids of World War II. Although each reconstruction resulted in a more modern city, Tokyo today presents a random pattern of the ancient and the ultramodern. At the center of the city is the Imperial Palace. Nearby is the National Diet building (1936). Toward the bay is the world-famous Ginza district. The Westernized Marunouchi district is home to many of Japan's multinational corporations. Komazawa Olympic Park contains structures designed by Kenzo TANGE for the 1964 Summer Games; Tokyo Dome stadium opened in 1988.

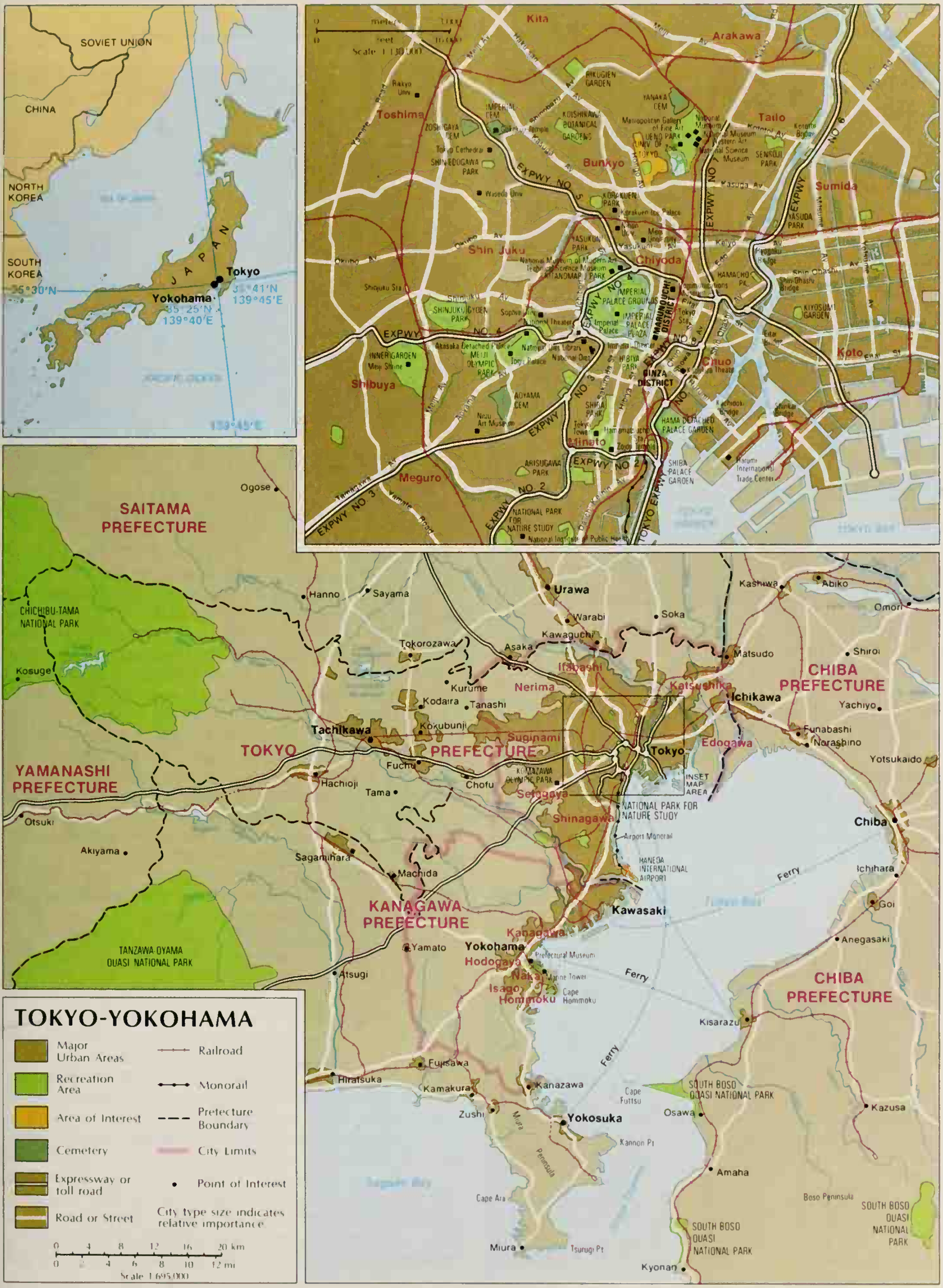
Tokyo, the capital of Japan and one of the great industrial cities of the world, is located on the eastern coast of Honshu, the largest of the Japanese islands. Tokyo formally became the nation's capital in 1868.

Tokyo suffers severe housing problems, and housing projects have been built in the outlying areas to encourage population dispersal. Tokyo prefecture has an elected governor and assembly, but the wards exercise a great deal of autonomy through their own elected councils.

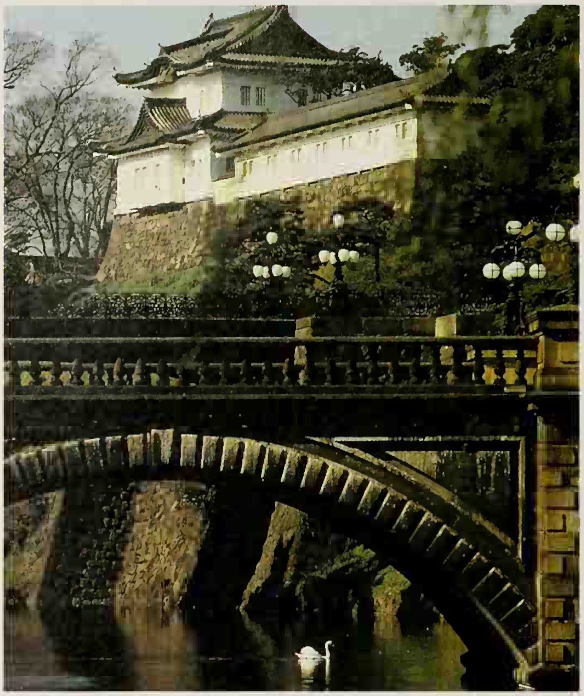
Economy. Tokyo is the commercial and industrial heart of Japan. It is also the nerve center of the country's international corporate activity. Within the city are manufactured many of the consumer products for which Japan is now famous. Tokyo is the hub of an extensive national railroad system. The harbors of Tokyo and Yokohama have been combined to form one administration named Keihin. Tokyo now handles primarily domestic trade.

Religion and Culture. Tokyo is a city of many shrines. The Meiji Shrine, dedicated to the Emperor Meiji (r. 1867–1912), is maintained in a beautiful garden setting. Within Tokyo's many parks, museums adjoin shrines and pagodas. The National Museum, the National Science Museum, the National Museum of Western Art, and the Metropolitan Gallery of Fine Art are in Ueno Park. The Technical Science Museum and the National Museum of Modern Art are located in Kitanomaru Park. Within Tokyo and its suburbs are more than 100 universities, including the University of Tokyo.

History. The city of Edo was established in the 12th century. In the 1590s, the local ruler Tokugawa IEYASU established control over the entire country and made himself (1603) shogun (military governor). Although the imperial capital remained in Kyoto, the real seat of government was Edo under the TOKUGAWA family. In 1853, Commodore Matthew PERRY directed U.S. warships into the bay to force the shogun to open Japan to Western commerce. In 1868 the shogunate surrendered power to the emperor, who moved the imperial court to Edo, renamed



TOKYO-YOKOHAMA



The Niju-bashi (Double Bridge) spans a moat surrounding the grounds of the Imperial Palace, residence of Japan's emperor. The Imperial Palace is located in the Chiyoda district of central Tokyo.

the city Tokyo ("Eastern capital"), and restored direct imperial rule (see MEIJI RESTORATION). By the time of the great earthquake of 1923, the population of Tokyo had exceeded 7 million. After the second destruction of Tokyo during World War II, the city became the administrative center of the U.S. occupation forces (1945–52). Since then Tokyo has had the highest rate of industrial growth among the world's major cities.

Tokyo Rose Tokyo Rose was the nickname given by U.S. troops in the Pacific to at least a dozen women who broadcast enemy propaganda and music to them from Japan during World War II. One of these women, Iva Ikuki Toguri D'Aquino, a U.S. citizen, was convicted of treason in 1949. Imprisoned until 1956, she steadfastly claimed to have worked under duress. On Jan. 19, 1977, President Gerald R. Ford granted her a pardon.

Toledo (Ohio) [tuh-lee'-doh] Toledo is a city in northwestern Ohio near the Michigan line, where the Maumee River empties into Lake Erie. The seat of Lucas County, Toledo has a population of 332,943 (1990), with 614,128 persons in the metropolitan area. Toledo is one of the major Great Lakes shipping ports, handling grain, coal, and iron ore. It is also an important petroleum-refining and industrial center and a leading producer of automotive parts and glass. The University of Toledo (1872) is located there, as are the Toledo Museum of Art, the Toledo Zoological Gardens, and an extensive park system.

The Battle of Fallen Timbers (1794), which hastened the collapse of Indian resistance in the area, was fought nearby. Soon afterward, Fort Industry was built in what is now downtown Toledo. In 1817, Port Lawrence was founded on the site. A dispute between Michigan Territory and the state of Ohio over inclusion of the Toledo area in Ohio's canal system led to the "Toledo War" of 1835. President Andrew Jackson decided the question in Ohio's favor. In return, Michigan was awarded the Upper Peninsula and granted statehood.

Toledo (Spain) [toh-lay'-doh] Toledo, a city in central Spain and the capital of the province of Toledo, lies on the Tagus River, about 70 km (40 mi) southwest of Madrid. Its population is 58,297 (1987 est.). The old city is a maze of narrow streets built on steep bluffs above the river and dominated by the Alcázar.

Although the traditional industries of sword manufacturing and engraved metalworking survive, Toledo's economy depends on tourism. Principal landmarks are the Gothic cathedral (begun 1227), the Franciscan friary of San Juan de los Reyes (1476), and the Alcázar, a fortress (rebuilt 1538). Also of historic significance are several medieval mosques and synagogues, two bridges over the Tagus River, a variety of 10th-to-16th-century gateways, and the city's medieval walls. Its museums and churches contain paintings by El Greco, Velázquez, Murillo, and other Spanish masters. Toledo is the seat of the archbishop primate of Spain.

Toledo was well established before conquest by the Romans in 192 BC. Roman Toletum was the provincial capital of Carpentia. The city served as capital of the Visigothic kingdom from the middle of the 6th century until it was captured by the Moors in 712. Its cultural and economic preeminence under Muslim rule did not end when Alfonso VI of León and Castile reconquered it in 1085. Christian, Arab, and Jewish culture blended in medieval Toledo and aided in the transmission of classical learning to western Europe. Toledo declined after Madrid became the Spanish capital in 1560. The city was a battleground during the War of the Spanish Succession (1701–14), the Peninsular War (1808–14), and the Spanish Civil War (1936), when the Nationalists defended the Alcázar.

Tolkien, J. R. R. [tohl'-keen] The English writer and scholar John Ronald Reuel Tolkien, b. Bloemfontein, South Africa, Jan. 3, 1892, d. Sept. 2, 1973, reestablished fantasy as a serious form in modern English literature. As professor of medieval English literature at Oxford University, he presented (1936) the influential lecture *"Beowulf:* The Monsters and the Critics," an aesthetic justification of the presence of the mythological creatures—Grendel and the dragon—in the medieval poem; he then went on to publish his own fantasy, *The Hobbit*

J. R. R. Tolkien is best known as the creator of Middle Earth, the world of his fantasy trilogy The Lord of the Rings. *A professor of Old English language and literature at Oxford University, Tolkien drew upon Nordic heritage to create the languages and myths of elves, dwarfs, and the homey creatures he called "hobbits."*

(1937). There followed his critical theory of fantasy, "On Fairy-Stories" (1939), and his masterpieces, the mythological romances *The Lord of the Rings* (1954–55) and *The Silmarillion* (1977).

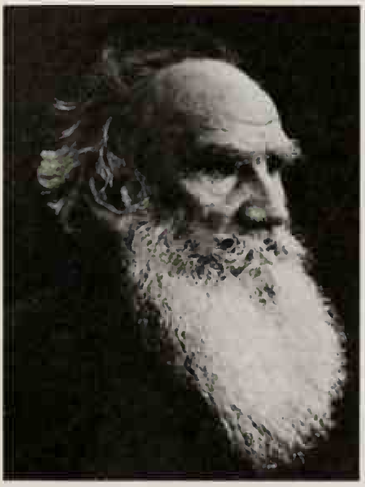
Tolkien was educated at King Edward's School in Birmingham and at Oxford. He saw action in the Battle of the Somme, but trench fever kept him frequently hospitalized during 1917. Inclination and profession moved Tolkien to study the heroic literature of northern Europe—*Beowulf*, the *Edda*, the *Kalevala*. The spirit of these poems and their languages underlies his humorous and whimsical writings, such as *Farmer Giles of Ham* (1949) and *The Adventures of Tom Bombadil* (1962), as well as his more substantial works.

Toller, Ernst [tohl'-ur] Ernst Toller, b. Dec. 1, 1893, d. May 22, 1939, was the most politically engaged representative of German left-wing expressionism. Besides being an active dramatist, he participated in the Bavarian Communist revolution of 1919 and served a 5-year prison sentence when it failed. A prime target of the Nazis, Toller left Germany even before Hitler's takeover. His most famous writings are the plays *Transfiguration* (1919; Eng. trans., 1935), about a soldier who after the war becomes a revolutionary; *The Machine-Wreckers* (1922; Eng. trans., 1923), which concerns the insurrection of the English weavers in 1812; and *Brokenbow* (1923; Eng. trans., 1926), about society's rejection of a returning soldier.

Tollund man [toh'-lund] Tollund man, the best preserved and most famous of the prehistoric corpses found in Scandinavian bogs, was unearthed in the Tollund peat bog of central Jutland, Denmark. The well-preserved corpse of this Iron Age man was clothed only in a cap, belt, and cloak. Because he had been hanged with a leather rope, it is presumed that he was a sacrificial victim. His stomach contents were sufficiently well preserved to show that his last meal had consisted of a gruel made of barley, linseed, knotweed, and other cultivated weeds; this evidence of a vegetarian diet has since been confirmed by other peat-bog burials. Bog burials of the Tollund type have been found in Denmark, Schleswig-Holstein, and Lower Saxony and span the period from around 100 BC to AD 500. Tollund man is now on display in the National Museum, Copenhagen.

Tolstoi, Aleksei Nikolayevich [tohl'-stoy or tuhl-stoy'] Soviet novelist Count Aleksei Nikolayevich Tolstoi, b. Jan. 10 (N.S.), 1883, d. Feb. 23, 1945, emigrated after the Bolshevik revolution of 1917 but in 1923 renounced his title and returned to the USSR. His early stories and novels portray the decaying gentry, as does his fictionalized autobiography, *Nikita's Childhood* (1921; Eng. trans., 1945). Both *Aelita* (1922) and *The Death Box* (1925; Eng. trans., 1936) combine science fiction and ideology. Tolstoi's two most influential works were the trilogy *The Road to Calvary* (1922–41; Eng. trans., 1945) and the unfinished *Peter the First* (1929–45; Eng. trans., 1956). The former gives a panoramic view of the years before World War I; the latter recounts the turmoil of Russia's westernization during the early 18th century.

Tolstoi, Count Leo Count Leo Tolstoi, b. Sept. 9 (N.S.), 1828, d. Nov. 22 (N.S.), 1910, was Russia's greatest novelist and one of its most influential moral philosophers. He was born near Moscow at Yasnaya Polyana, or "Clear Glade," the estate where he was to spend most of his life. At the age of nine he became an orphan, and thereafter he was raised by aunts. In 1847 he left the University of Kazan to reform his estate, but he was un-



Count Leo Tolstoi, considered one of the greatest figures of world literature, was a major influence on late-19th-century Russian thought. Although moral and religious didacticism pervade much of his later work, Tolstoi's descriptive genius and psychological acuity, best displayed in War and Peace *(1865–69) and* Anna Karenina *(1875–76), remain the vital force in all his writings.*

prepared for the task and moved to Moscow. Five years later, Tolstoi volunteered for the army in the Caucasus; he participated in the defense of Sevastopol and was hailed as a rising literary star for his fictionalized *Childhood* (1852; Eng. trans., 1862), *Youth* (1857; Eng. trans., 1862), and *Sevastopol Sketches* (1855–56; Eng. trans., 1888), which already contained some of the main features of his mature work—psychological analysis of unprecedented detail, and a description of war that seeks to replace romanticized glory with a realistic view of battle as unglamorous actions performed by ordinary men.

Philosophy. Tolstoi retired from the army in 1856, traveled in Europe, and returned to his estate, where he founded a school for peasant children that anticipated several modern educational practices. He was married in 1862 and a year later published a novel he had begun much earlier, *The Cossacks* (1863; Eng. trans., 1878). During this period he wrote the novels on which most of his fame rests: WAR AND PEACE and ANNA KARENINA. A deep-seated dissatisfaction with himself and a long-frustrated search for meaning in life, however, led to the crisis Tolstoi described in his *Confession* (1879; Eng. trans., 1921) and *Memoirs of a Madman* (1884; Eng. trans., 1943). In these works he also formulated a doctrine to live by, based on nonresistance to evil, renunciation of wealth, self-improvement through physical work, and nonparticipation in such social phenomena as war and juries.

The doctrine had an enormous vogue, profoundly influencing Mahatma Gandhi, among others. Yasnaya Polyana became a place of pilgrimage, and Tolstoi was revered and emulated throughout the world. Constant strife, however, existed between Tolstoi's wife and his followers; finally, after many scenes, Tolstoi left the estate in October 1910, became ill, and died at nearby Astapovo a few weeks later.

War and Peace, and Anna Karenina. In *War and Peace* (1865–69), Tolstoi chronicled the histories of several families against the backdrop of the Napoleonic Wars. The leading characters—Prince Andrei, Pierre, and Natasha—develop and grow into maturity and are finally integrated into the process of life, which they accept as the answer to their personal searches for meaning.

Anna Karenina (1875–77) also weaves together several plots. Anna gives up family and social position to live with her lover, Vronsky, and her brother's less consuming adulterous passions lead to marital strife. The courtship and rewarding marriage of Levin and Kitty, based on Tolstoi's own experience, provide a contrast. Although the novel's scope is smaller than that of *War and Peace*, and its techniques differ, it also presents an extensive picture of Russia.

Later Works. After arriving at his doctrine of nonresistance and nonparticipation, Tolstoi at first refrained from writing fiction. He expounded his philosophy in a series of tracts, including *What Is Art?* (1897; Eng. trans., 1898), which renounced much of his earlier work as too complex and not morally uplifting. He returned to imaginative literature, however. The theme of death, already vital in his early writings, is reexamined in his most influential study, *The Death of Ivan Ilych* (1886; Eng. trans., 1888), a ruthless and appalling depiction of a life void of meaning, and in *Master and Man* (1895; Eng. trans., 1895). Tolstoi had once described sexual desire naturally and vividly, but now he preached sexual abstinence and wrote on the conflict of passion and morality in *The Devil* (1889; Eng. trans. 1926), *The Kreutzer Sonata* (1890; Eng. trans., 1890), and *Father Sergius* (1898; Eng. trans., 1912). His last novel, *Resurrection* (1899; Eng. trans., 1899), published to aid a dissident sect, includes memorable scenes in the courts and jails of Moscow but is flawed by didactic intrusions. He returned to earlier themes and techniques in the novella *Hadji Murad* (1904; Eng. trans., 1912).

Toltec [tahl'-tek] The Toltecs, an ancient people of MESOAMERICA, dominated central Mexico from the 10th until the mid-12th century AD. Many of the region's later peoples claimed descent, notably the AZTECS, who told Spanish conquerors about the Toltecs.

The Toltecs moved into the Valley of Mexico after the collapse of TEOTIHUACÁN in the late 7th century left a power vacuum. They quickly developed trade routes that reached from modern-day Costa Rica to the American Southwest. By the 9th century the Toltecs were established at TULA. For at least a century, the Toltecs shared profound contacts with CHICHÉN ITZÁ in Yucatán. According to both central Mexican and Maya annals, the Toltec king QUETZALCÓATL fled Tula and went to Yucatán in 987. Although there is no evidence that one conquered the other, similar art and architecture appeared at both Tula and Chichén.

In the 12th century, Toltec power waned as droughts disrupted agriculture and Tula came under heavy pressure from displaced peoples. About 1150, Tula was destroyed. Some Toltecs fled to the Valley of Mexico, where their lineages bore great prestige in the Aztec era.

Toluca [toh-loo'-kah] Toluca (1980 pop., 357,071), the capital of the state of Mexico in central Mexico, lies about 65 km (40 mi) southeast of Mexico City. The city is an agricultural and manufacturing center as well as a summer resort. Founded by the Spanish in 1530, it was long the fiefdom of the Cortés family.

Tom Jones *Tom Jones* (1749; film, 1963) is the finest novel of Henry FIELDING. By humorously deploying the devices of mock epic and romance and by giving his narrative a wide social range, Fielding opened the way for the novels of Dickens, George Eliot, and Thackeray. *Tom Jones* recounts the adventures of the foundling Tom, a generous but hot-blooded young man who is temporarily banished by his benefactor, Squire Allworthy, through the deviousness of the odious Blifil, his rival for the hand of Sophia. The explosive Squire Western, saintly schoolmaster Partridge, and amorous Lady Bellaston are among the memorable characters of the novel, which Fielding infused with a morality of relaxed Christian benevolence.

Tom Sawyer One of Mark Twain's most popular novels, *The Adventures of Tom Sawyer* (1876) captures the spirit of boyhood as it was experienced in a small Mississippi River town in mid-19th-century Missouri. Being out of favor with his Aunt Polly and his sweetheart Becky Thatcher, Tom is plunged into a series of adventures, which begin in a graveyard when he and Huck Finn witness a murder committed by the half-breed Injun Joe. They continue through the boys' escape to a nearby island, their attendance at their own funeral when the townspeople believe them dead, Tom's crucial testimony at the murder trial of an innocent man, his reconciliation with his aunt, and Tom and Becky's disappearance in a cave in which Injun Joe is lurking. *Tom Sawyer* inspired three sequels, of which Huckleberry Finn alone is of major significance.

Tom Thumb (entertainer) General Tom Thumb was the stage name of Charles Sherwood Stratton, b. Bridgeport, Conn., Jan. 4, 1838, d. July 15, 1883, the 63.5-cm (25-in) midget discovered in 1842 by the showman P. T. Barnum. Growing to 101.5 cm (40 in) at maturity, Tom Thumb toured extensively.

Tom Thumb (locomotive) see locomotive

tomahawk *Tomahawk* is an Algonquian term for a type of striking or throwing weapon. Originally the tomahawk consisted of a carved wooden club about 60 cm (2 ft) long with a 15-cm (6-in) ball of sculptured wood, beryl, or bone attached at its striking end by thongs. These weapons were widely used in hunting and warfare by the aboriginal inhabitants of the northeastern United States, the Great Lakes, and the upper Saint Lawrence region of Canada. With the coming of European trade goods, a knife was sometimes inserted into the ball of the war club. Eventually, commercial tomahawks, in which a metal ax blade replaced the ball, were imported for sale to the Indians. At the end of hostilities among Indians the tomahawk was frequently buried as part of the peace ceremony, giving rise to the expression "bury the hatchet" to indicate the end of a disagreement.

tomato Tomato is the common name for a perennial herb, *Lycopersicon lycopersicum*, of the nightshade family, Solanaceae, and for its edible fruit. Like the potato and the green pepper, to which it is closely related, the tomato originated in Central America. Spanish explorers introduced tomato seeds into Europe and North America, but the "love apple" did not become popular in either area until the 19th century.

Botanically, the tomato is a fruit, but for purposes of trade it is classified as a vegetable. Because tomatoes are warm-season plants and sensitive to frosts, they are grown as annuals in temperate climates. Rich in potassium and vitamins A and C, varieties range in size from 2 cm (less than 1 in) in diameter to more than 15 cm (6 in); in color from white to yellow to orange to deep red; in shape from oval to oblong to teardrop; and in flavor from highly acidic to very sweet. They are cultivated commercially in every U.S. state except Alaska.

The tomato became popular in the United States only in the 19th century. Illustrated are (left) *a plant with large-fruited red tomatoes in various stages of ripeness;* (upper left) *flowers and newly set fruit;* (upper middle) *the large-fruited red tomato, which is the most common variety;* (lower middle) *yellow large-fruited and pear tomatoes;* (upper right) *cherry tomatoes; and* (lower right) *the Italian plum tomato, used in Italian sauces and pastes.*

Tomatoes are the most widely used canned vegetable in the United States. About 75 percent of the total crop is processed into juice, canned tomatoes, sauces, pastes, and catsup. Varieties have been developed with qualities that make them harvestable by machine; they all ripen simultaneously and have tough skins and a squarish shape. In the United States, California, Michigan, and Ohio lead in growing processing tomatoes. Florida is the leading producer of fresh tomatoes. Some of the fresh produce available in winter is imported from Mexico and Israel, or from Dutch greenhouses.

tomb A tomb is a place of burial, in the form of a sarcophagus, crypt, vault, or chamber, located either above or below ground. The term *tomb* also refers to monuments erected over graves to commemorate the dead. Chamber tombs built of huge boulders or smaller stones were constructed in many parts of prehistoric Europe from about 4000 to 1000 BC (see European prehistory). They were often used for collective burials and were usually covered with a mound of earth or piled-up stones. The most common types of stone-built chamber tombs are the gallery grave, a single axial chamber, and the passage grave, a round, square, or irregularly shaped chamber entered through a narrow, stone-faced passage (see megalith).

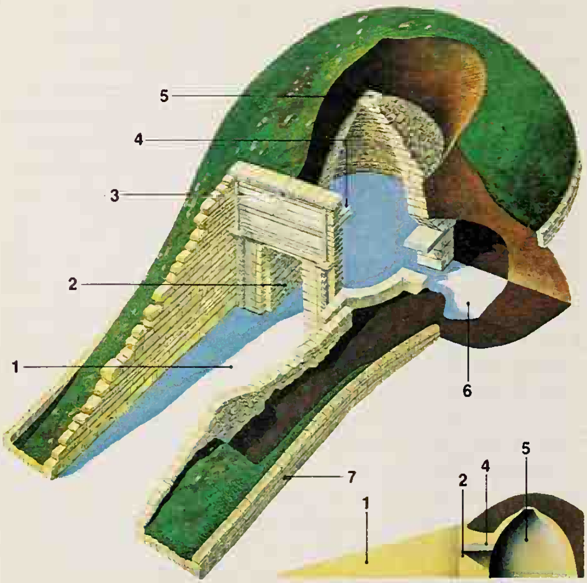
In ancient Egypt the earliest monumental tomb was the mastaba of the Predynastic Period (*c.*3500–3100 BC), a rectangular structure with a flat top and either stepped or sloping sides. By about 3000 BC the pyramids came into use as tomb monuments, the most spectacular being those of the Old Kingdom rulers Khufu, Khafre, and Menkaure, at Giza. During the New Kingdom (1570–1085

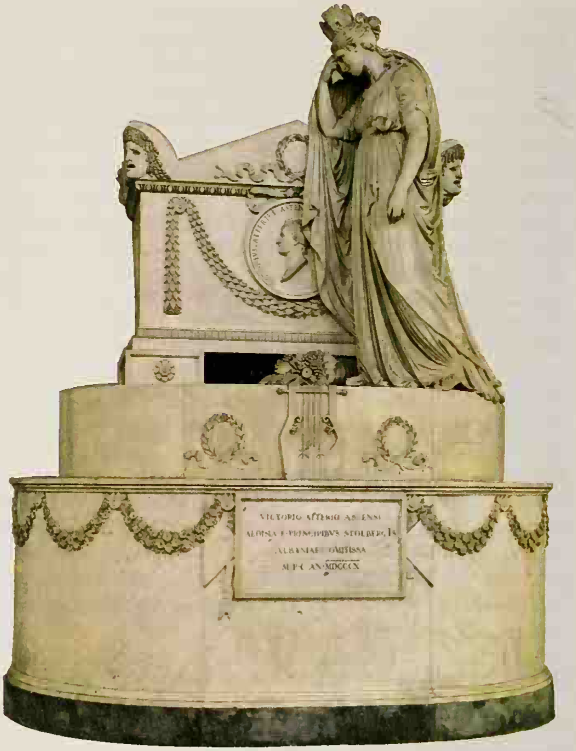
BC), royal dead often were buried in rock-cut tombs excavated deep into the sides of mountains. A notable example is the tomb of Queen Hatshepsut at DEIR EL-BAHRI.

The most impressive tombs associated with ancient AEGEAN CIVILIZATION are beehive-shaped stone chambers called *tholoi*. The largest and best preserved of these corbel-roofed structures, the so-called Treasury of Atreus (late 14th century BC), at MYCENAE, rises to a height of about 13.5 m (45 ft). Classical Greek tombs dating from the 5th century BC often were marked by a STELE, an upright stone slab usually bearing a commemorative inscription and sometimes also fine relief decoration. Among the most magnificent tombs of ancient times was the structure built (*c.*350 BC) at Halicarnassus (modern Bodrum, Turkey) for Mausolus, the ruler of Caria, and his spouse, Artemisia. The colonnaded edifice, now almost totally destroyed, was about 50 m (165 ft) high and was surmounted by a truncated pyramid supporting a four-horse chariot. Considered one of the SEVEN WONDERS OF THE WORLD, the Mausoleum of Halicarnassus is the origin of the term *mausoleum*, which may be applied to any aboveground architectural funerary monument.

In the ancient Mediterranean world the large underground chamber tombs of the ETRUSCANS often were furnished with rich fresco-type wall paintings illustrating mythological themes as well as scenes from daily life. Notable Roman tombs include the remarkable sepulcher of the baker Eurysaces and his wife, built (*c.*60 BC) in the shape of an enormous baker's oven, and the marble-sheathed mausoleum of Hadrian (now called the CASTEL SANT'ANGELO; see ROMAN ART AND ARCHITECTURE). Niches in the walls of the narrow subterranean passages of Rome's CATACOMBS served as a place of Christian burial from the 2d to the 5th century (see EARLY CHRISTIAN ART AND ARCHITECTURE).

This cutaway diagram illustrates the construction of the Treasury of Atreus (14th century BC), the largest Mycenaean domed tomb. The dromos (1), *a long, narrow, uncovered passage, leads to an entrance* (2) *with a facade* (3), *supported by a double lintel* (4) *and once embellished with colored stone pilasters. The tholos* (5) *is adjoined by a side chamber* (6) *that was the actual burial crypt. A retaining wall* (7) *surrounded the base of the mound covering the tomb.*





The formality and elegant simplicity of the funerary monument (finished 1810) of the Italian poet Vittorio Alfieri by Antonio Canova reflects the influence of ancient Roman art. (Santa Croce, Florence.)

Among cultures of the East, the most elaborate Chinese tombs date from the Qin (221–206 BC) and Han (202 BC–AD 220) dynasties, when vaulted underground burial chambers often were richly furnished with mural paintings and relief work and with great quantities of funerary sculpture (see CHINESE ART AND ARCHITECTURE). In Japan, during the protohistoric Tumulus period (AD 250–500), royal tombs were surmounted by immense artificial mounds (tumuli) up to about 2,500 m (8,202 ft) in circumference and 20 m (66 ft) in height (see JAPANESE ART AND ARCHITECTURE).

In the Islamic world, large, often lavish tomb monuments were built, beginning in the 10th century, for rulers and members of their families. An early masterpiece in central Asia is the brick-walled royal mausoleum of the Samanids (*c.*940; Bukhara, Uzbek SSR). The most famous Muslim tomb monument is the 17th-century TAJ MAHAL, in

Agra, India, built for the favorite wife of the Mogul ruler Shah Jahan (see Mogul art and architecture).

Throughout the Middle Ages and the Renaissance period in Europe, important persons commonly were entombed in a sarcophagus, crypt, or shrine within a church. Frequently placed on top of the tomb was an effigy sculpture of the deceased, represented kneeling in prayer or as a gisant (a reclining figure usually shown lying in repose or in the form of a decaying corpse). A splendid example of late-16th-century sepulchral sculpture is Germain Pilon's monumental tomb of Henry II and Catherine de Médicis (1565–72; Abbey of Saint-Denis, Paris), in which appear two pairs of idealized statues of the couple—one pair as living and one as dead.

During the baroque and neoclassical periods tomb monuments often displayed a complex tableau of sculptures intended as a dramatic allegorical statement about life and death, as in François Girardon's tomb of Richelieu (begun 1675; Church of the Sorbonne, Paris). With the work of Antonio Canova and other neoclassical sculptors, religious symbols began to disappear almost entirely from tomb monuments. After the 18th century fewer and fewer tombs were placed inside churches. Important personages were buried mainly in churchyards, such as the famous Père Lachaise in Paris, or in specially erected mausoleums. Notable 19th- and 20th-century tombs include that of Napoleon, in the Dome des Invalides in Paris; Ulysses S. Grant's tomb, in New York City; and the Lenin Mausoleum, in Red Square, Moscow. Several countries honor their war dead with tombs for the unknown soldier.

Tombaugh, Clyde William [tahm'-baw] The American astronomer Clyde W. Tombaugh, b. Streator, Ill., Feb. 4, 1906, is known for his discovery of the planet Pluto. As an assistant at Lowell Observatory, Tombaugh continued Percival Lowell's search for a planet beyond Neptune. Using a blink microscope to compare the positions of star images on photographic plates, Tombaugh detected Pluto on Feb. 18, 1930. He subsequently obtained degrees from the University of Kansas (1936, 1939) and Arizona State University (1960) and has been a member of the astronomy department at New Mexico State University since 1955.

Tombigbee River [tahm-big'-bee] The Tombigbee River, about 845 km (525 mi) long, is a tributary of the Mobile River in Alabama. From Mississippi the Tombigbee flows southeast into Alabama, joining the Alabama River to form the Mobile River. The Tennessee-Tombigbee Waterway, opened in 1985, utilizes a stretch of the Tombigbee to connect the Tennessee River with the Gulf of Mexico.

Tombstone Tombstone (1990 pop., 1,220), a city in southeastern Arizona, about 105 km (65 mi) southeast of Tucson, is famous for its past as a lawless silver-mining center of the 1880s. The Bird Cage Theater, the O.K. Corral, and Boothill Graveyard are the main tourist attractions. The city was declared a national historic landmark in 1962.

tombstone Tombstones are markers erected at the head or, less often, the foot of a grave for the purposes of commemorating the individual buried there. They have been used in various cultures for centuries. Because tombs, murals, and other monuments were too expensive for all but the rich, tombstones became the most popular form of marker for the middle class. Of particular interest because of their elaborate carvings and unusual epitaphs (inscriptions) are the tombstones of England and New England dating from the late 17th to the early 19th century. Among the many different motifs used on these markers, the three most common were the skull-faced death's head (17th to early 18th century), the cherubic-faced winged angel (mid-18th century), and the urn-and-willow (late 18th to early 19th century) (see folk art).

Tompkins, Daniel D. Daniel D. Tompkins, b. Scarsdale, N.Y., June 21, 1774, d. June 11, 1825, was vice-president of the United States (1817–25) under James Monroe. He was a New York supreme court justice (1804–07) and subsequently promoted democratic reforms as the state's governor (1807–17). Throughout the War of 1812 he had to contend with a recalcitrant Federalist contingent in the legislature and the threat of a British invasion from Canada. During his vice-presidency Tompkins was occupied with a long controversy arising out of charges that he had mishandled funds while serving as governor.

tonality In its broadest sense, tonality in music means a sense of tonal gravity by which the listener consciously or subconsciously perceives that the main musical impulses arise from and flow toward one or a limited number of tone centers, the most important of these being the point of ultimate repose. In its more commonly used meaning, however, tonality is synonymous with key and refers to the use of the melodic and harmonic vocabulary of the major-and-minor system prevalent in music since the 17th century (see also atonality). The main tonal center is established by the triad based on the tonic, or key note, which is the first step of the scale. The second important tonal center is the dominant, or fifth step of the scale; a possible third center is the subdominant, the fourth scale step. Chords based on these tonal centers perform specific functions and ultimately serve to strengthen the tonic (key note).

Tone, Wolfe [tohn] An Irish patriot, Theobald Wolfe Tone, b. June 20, 1763, d. Nov. 19, 1798, was the most colorful leader of the Society of United Irishmen. In 1791 he turned from an undistinguished legal career to help found the society, which eventually came to advocate Irish independence from Britain. Tone left Ireland in

1795 to avoid prosecution, and he began soliciting military assistance from revolutionary France for the United Irish cause. He accompanied an abortive French expedition to the Irish coast in December 1796. During the Irish rebellion of 1798, Tone was captured; he committed suicide while awaiting execution for treason.

tone poem see SYMPHONIC POEM

tong A tong is a community or fraternal organization of Chinese in the United States. The first tongs were founded in the 1850s; they functioned as secret societies for immigrants, primarily those from the Guangzhou region. The term is derived from the Chinese word for "hall" or "reception room." In such meeting places, family elders and village officials in China traditionally gathered to make decisions and set community policies; the word could also mean "court of justice."

When the Chinese first arrived in North America they discovered that their new environment was harsh, with many economic, political, and social restrictions. To aid and protect themselves many Chinese banded together in communal groups based on former village structures and ties. In time, competition between the various tongs resulted in much-publicized violence. These internecine wars grew to such proportions that in 1933 the U.S. government intervened and deported large numbers of their members. Today the role of the tongs is reduced and their power curtailed.

See also: ASIAN AMERICANS.

Tonga [tahng'-guh] The Kingdom of Tonga is a former British protectorate that gained independence within the Commonwealth of Nations on June 4, 1970. The kingdom is composed of an archipelago of more than 150 islands about 640 km (400 mi) east of Fiji in the South Pacific Ocean. Nukualofa is the capital.

Land, People, and Economy

Two parallel island chains extend in a north-south direction. Those to the west are volcanic and those to the east, limestone. They are divided into three major groups: Vavau in the north, Haapai in the center, and Tongatapu to the south. The limestone islands have fertile soils partially derived from volcanic ash. Average temperatures range from 24° C (75° F) in the north to 23° C (73° F) in the south, and rainfall varies from 2,286 mm (90 in) in Vavau to 1,702 mm (67 in) in Tongatapu.

The Tongans are Polynesians and speak a language derived from Samoan. The majority of the population is Christian. Education and health care are free, and literacy is high.

Tonga is an agricultural country with copra, bananas, and vanilla the principal exports. Small-scale manufacturing and the fishing industry have expanded steadily, and tourism and remittances from Tongan workers abroad help to offset the country's large trade deficit. Tonga also receives substantial foreign aid.

Government and History

The monarch and his or her privy council (including the

AT A GLANCE

KINGDOM OF TONGA

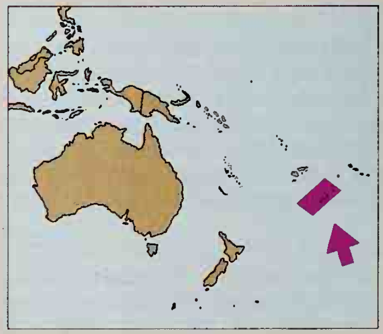
Land: Area: 699 km^2 (270 mi^2). Capital and largest city: Nukualofa (1986 pop., 21,383).

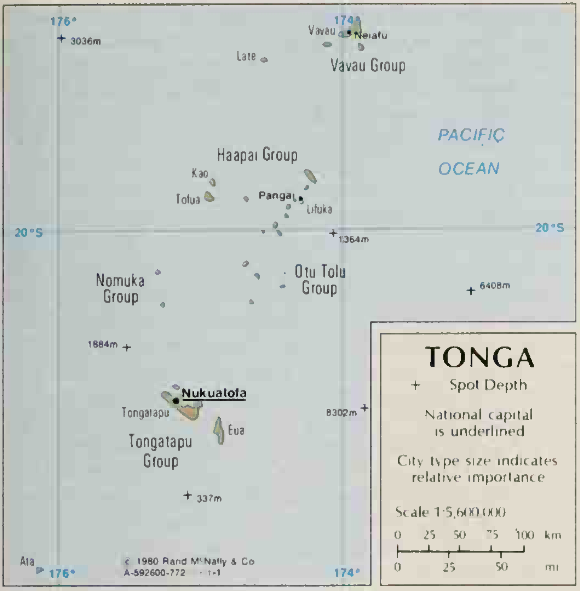
People: Population (1990 est.): 101,313. Density: 145 persons per km^2 (375 per mi^2). Distribution (1986): 31% urban, 69% rural. Official languages: Tongan, English. Major religion: Christianity.

Government: Type: constitutional monarchy. Legislature: Legislative Assembly. Political subdivisions: 3 main island groups.

Economy: GNP (1989): $89 million; $910 per capita. Labor distribution (1986): agriculture and fishing—75%; other—25%. Foreign trade (1988 est.): imports—$60.1 million; exports—$9.1 million. Currency: 1 pa'anga (Tongan dollar) = 100 seniti.

Education and Health: Literacy (1986 est.): 90–95% of adult population. Universities (1987): none. Hospital beds (1989): 307. Physicians (1989): 45. Life expectancy (1990): women—70; men—65. Infant mortality (1990): 24 per 1,000 live births.





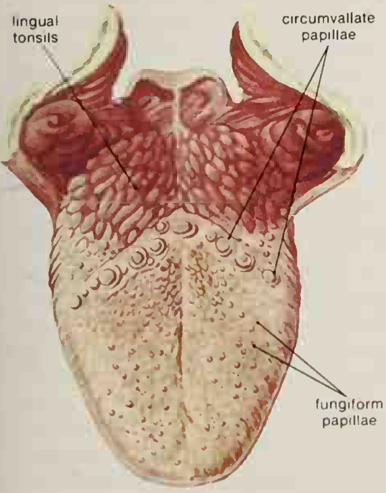
prime minister) form the executive branch of government. A majority of the legislative assembly is popularly elected.

Capt. James Cook arrived there in 1773 and named the archipelago the "Friendly Islands." A constitutional monarchy was established by King George Tupou I in 1875, and Tonga became a British protectorate in 1900. The present monarch is King Taufa'ahau Tupou IV, who succeeded his mother, Queen Salote, in 1965.

tongue The tongue, a muscular organ in the mouth, provides the sense of taste and assists in chewing, swallowing, and speaking. It is firmly anchored by connective tissues to the front and side walls of the pharynx, or throat, and to the hyoid bone in the neck. The front two-thirds of the tongue, called the body, is demarcated from the back one-third, called the root, by a V-shaped boundary. The upper surface of the body of the tongue has numerous raised projections called papillae. The upper surface of the sides of the root of the tongue exhibits irregular bulgings called the lingual TONSILS.

Three types of papillae are prominent in adult humans. A fourth type, foliate papillae, is rudimentary in humans but is well developed in many animals. The most numerous type, filiform, functions mainly to provide friction to help in the movement of food. Scattered among these are the second most abundant type, the fungiform papillae. These knoblike projections, located mostly on the upper central area of the tongue, contain the taste buds. The third type, the vallate, or circumvallate, papillae, is the largest and also contains taste buds. About 13 in number, they occur in the V-shaped row that demarcates the body from the root of the tongue.

See also: TASTE AND SMELL.



The human tongue is a mass of skeletal muscle covered by a mucous membrane. The anterior section contains papillae, which house the taste buds. Filiform papillae are long and thin, and fungiform papillae are shaped like mushroom caps. Circumvallate papillae are flattened structures found in front of the root, which is covered by the lingual tonsils.

tongues, speaking in Speaking in tongues (glossolalia) is a Christian religious phenomenon in which the believer, in an ecstatic state, speaks in a foreign language or utters unintelligible sounds that are taken to contain a divine message. Many Christians believe the genuine gift of tongues to have been confined to earliest Christianity, at PENTECOST, and during conversion experiences. Modern revivalist movements such as the Pentacostalists and Charismatics believe it to be given in contemporary times as a testimony to the special presence of the HOLY SPIRIT. Many psychologists explain the phenomenon as a hypnotic trance that results from religious excitement.

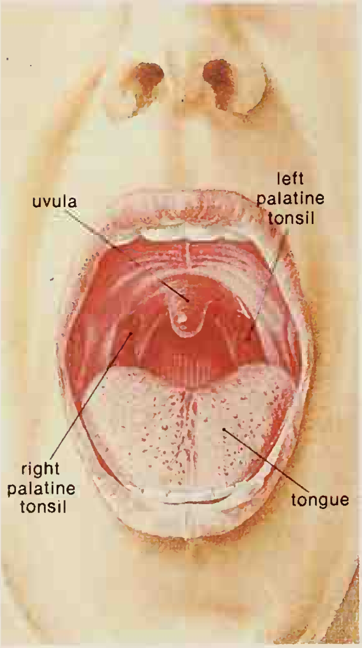
Tonkin see VIETNAM

Tonkin, Gulf of [tahng'-kin] The Gulf of Tonkin is a shallow, irregularly shaped extension of the South China Sea, about 50 km (300 mi) long and 250 km (150 mi) wide. It is bordered on the north and east by China and on the west by Vietnam. The main port is HAIPHONG in Vietnam.

Tonkin Gulf Resolution On Aug. 5, 1964, U.S. president Lyndon B. Johnson placed before Congress a measure, known as the Tonkin Gulf Resolution, that gave the president broad powers in responding to attacks on American forces and that served as the basis for the subsequent increasing involvement of the United States in the VIETNAM WAR. The resolution, passed two days later by both houses of Congress with only two "no" votes (by senators Wayne Morse and Ernest Gruening), was a response to alleged attacks earlier in August by North Vietnamese torpedo boats on the U.S. destroyers *Maddox* and *C. Turner Joy*, which were operating in the Gulf of Tonkin. Although the American ships were not damaged, retaliation against the North Vietnamese was carried out quickly and on a large scale. As disaffection with the role of the United States in Vietnam grew, many members of Congress questioned the wisdom of the measure, and in 1967 the Senate Foreign Relations Committee conducted an investigation into the matter. Congress repealed the Tonkin Gulf Resolution on Dec. 31, 1970.

tonsillitis Tonsillitis is an acute or chronic inflammation of the tonsils, located near the back of the tongue. (The adenoids, lymph glands located behind the nose, are often simultaneously inflamed.) Tonsillitis, which usually develops suddenly as a result of a streptococcal infection but may also be caused by a viral infection, is characterized by sore throat, fever, chills, headache, poor appetite, and weakness. The tonsils become swollen and red, with streaks of pus often visible on their surface. Acute tonsillitis normally clears up in about a week, but antibiotics are often administered to prevent complications. In chronic tonsillitis the tonsils tend to flare up in episodes of acute infection; the usual treatment is surgical removal. Tonsillitis is more common in children than in adults.

tonsils Tonsils are spongy lymphoid tissues at the back of the throat, composed mainly of lymphocytic cells held together by fibrous connective tissue. There are three types. The palatine tonsils, usually referred to as "the tonsils," are visible between the arches that extend from the uvula (bell-shaped structure) to the floor of the mouth. The pharyngeal tonsils, usually referred to as the adenoids, lie at the back of the throat. The lingual tonsils are on the upper surface of each side of the back of the TONGUE. The tonsils function to protect the body from infectious organisms. Chronic or acute inflammation of the tonsils, called tonsillitis, may serve as a source of infection elsewhere in the body.



Tonsils are located at the back of the throat. Composed of lymphoid tissue, they help defend the body against disease organisms, such as bacteria and viruses, carried in the air. The tonsils form lymphocytes—white blood cells that produce antibodies—which combat harmful organisms trapped in the mucous membrane lining the mouth, nose, and throat. The palatine tonsils are located on both sides of the back of the mouth.

tonsure [tahn'-shur] Tonsure (from Latin, "to shave") is the ritual practice found in many cultures of clipping hair from the head to mark a transition in life, usually in a religious context. In Buddhism, Hinduism, Jainism, and Christianity it is part of the initiation into monastic life or the priesthood. Christian tonsure is found as early as the 4th century. In the Eastern church the whole head was traditionally shaved, although more recently the hair is merely cut close. In the West a dispute arose (6th and 7th centuries) between the Roman church, which shaved the crown of the head, leaving a fringe of hair around the outer portion of the head, and the Celtic church, which shaved the front of the head. The Roman practice dominated. Tonsure was abolished by the Roman Catholic church in 1972.

Tonty, Henri de [tahn-tee'] Henri de Tonty (or Tonti), b. probably in Paris, *c.*1650, d. September 1704, fur trader and explorer, tirelessly promoted French interests in the interior of North America. As lieutenant of Robert Cavelier, sieur de LA SALLE, Tonty supervised (1679–80) the construction of Fort Conti below Niagara Falls, of the ship the *Griffon* on Lake Erie, and of Fort Crévecoeur on the Illinois River. In 1682, Tonty and La Salle followed the Mississippi to its mouth, returning north to build Fort Saint Louis on the Illinois and to persuade the tribes of the region to move close to the fort. In 1684 he helped to hold off an Iroquois attack on the Illinois country, but in 1687 he could mobilize only 80 Illinois warriors to assist in an offensive against the Iroquois. Having been unable to find La Salle at the mouth of the Mississippi in 1686, Tonty learned only 3 years later of his superior's death. From 1690 to 1700 he traded in the Illinois country and then helped Pierre Le Moyne, sieur d'IBERVILLE, establish a post at the mouth of the Mississippi. He subsequently worked to keep the allegiance of the Indians of that region to French interests.

Tony Awards The Tony Awards, the most prestigious of American stage awards, honor distinguished achievement in 27 categories of theater production. Winners receive medallions from the League of New York Theatres and Producers on behalf of the American Theatre Wing, which established the annual presentations in 1947 to honor its former chairwoman, the actress, director, and producer Antoinette Perry (1888–1946).

Tooker, George George Tooker, b. Brooklyn, N.Y., Aug. 5, 1920, is an American realist painter whose work has a strongly surrealist quality. Set in anonymous contemporary architectural vistas, Tooker's subject is the paranoiac feelings of the contemporary city dweller. In *The Subway* (1950; Whitney Museum of American Art, New York City), one sees a woman becoming aware of her isolation and the menace of an aseptic subway station peopled with ominous, threatening figures. Most of Tooker's work is executed in egg tempera, which allows him to achieve the greatest possible realism in his work.

tool and die making Tool and die making is a very highly skilled trade in which a machinist uses machine tools, hand tools, and grinding and polishing equipment to make such tools as jigs, fixtures, and dies. The enormous quantities of modern metal products—kitchen utensils, refrigerators, and automobiles, for instance—are the direct result of the expertise of machinists in the tool and die maker's trade.

The term *die* in metalworking usually refers to a production device used to produce piece parts from sheet metal by punching, shearing, bending, or drawing. Forging dies are also used for forming hot metals under pressure. Thread-cutting tools, used to make external threads on bolts, are also called dies. Tooling includes holding-fixtures for workpieces and jigs, which are used to guide cutting tools into the workpiece.

A die set consists of two die plates, the upper of which is called a punch holder and the lower of which is called a die plate. The punch of a press tool enters into an opening or cavity, which is part of the die. A punch press is a machine that forces the two halves of the die together to rapidly produce identical parts from sheet metal. Dies are made from special tool steels that are often hardened and tempered after machining, and they are subsequently ground and finished to very close tolerances and smooth finishes.

The tool and die maker removes stock from the tool steel blank by band sawing, milling, and drilling and by using other metal-cutting machines such as a die sinker. Nontraditional machining methods are rapidly displacing the use of machine tools for die making.

Toombs, Robert An American representative and senator, Robert Augustus Toombs, b. near Washington, Ga., July 2, 1810, d. Dec. 15, 1885, was a Confederate leader during the U.S. Civil War. Toombs served in the Georgia legislature (1837–40, 1841–44) and the U.S. House of Representatives (1845–53) before entering (1853) the Senate. A Whig until 1850, he became a Democrat and a leading defender of Southern rights.

In 1861, realizing that the Republicans would never permit the expansion of slavery, Toombs became a secessionist, withdrew from the Senate, and served as Jefferson Davis's secretary of state. Unhappy in that post, Toombs resigned in July 1861 and was made a general. Not receiving a promotion after playing a prominent role in the Battle of Antietam (1862), he resigned from the army and became an outspoken critic of the Davis administration. In 1865, Toombs fled to Cuba and then to Europe. He returned to Georgia in 1867 and resumed the practice of law.

Toomer, Jean The writer Jean Toomer, b. Washington, D.C., Dec. 26, 1894, d. Mar. 30, 1967, is best known for his experimental novel, *Cane* (1923), a thematically unified collection of short fiction, poetry, and drama that juxtaposes the lives of Southern rural blacks with those of their Northern urban counterparts. A prominent figure in the Harlem Renaissance, Toomer abandoned writing after *Cane*'s initial lukewarm reception and retreated with his wife to southeastern Pennsylvania.

tooth decay see teeth

topaz Topaz, an aluminum silicate mineral $[Al_2(F,OH)_2SiO_4]$, is a highly valued gemstone and the traditional birthstone for November. It forms colorless to straw yellow, bluish or brown, transparent to subtranslucent prismatic crystals (orthorhombic system). Topaz occurs in high-temperature veins, in pegmatites, and in granites and rhyolites, where it is one of the last minerals to form. Hardness is 8, luster is vitreous, and specific gravity is 3.4 to 3.6; it has one highly perfect cleavage.

Topaz (left) *is a transparent aluminum fluorosilicate mineral that occurs as hard prismatic crystals of various colors. Long prized as a gemstone, the golden variety in particular is cut into brilliant faceted jewels* (right).

Topeka [tuh-pee'-kuh] Topeka is the capital and third largest city of Kansas. Located in the northeastern part of the state and bisected by the Kansas River, the city is the seat of Shawnee County and has a population of 119,883 (1990). Topeka is a rail hub and an important shipping and marketing center for the farm products of the surrounding rich agricultural region. The city has varied industries, including flour, tire, and pharmaceutical manufacturing and meat-packing plants. Topeka is the site of Washburn University (1865) and of the Menninger Clinic.

Topeka was founded in 1854 by antislavery colonists led by Charles Robinson and Cyrus Holliday. Holliday later chose the city as the terminus for his railroad—the

Atchison, Topeka, and Santa Fe. The city was a center of conflict between free-soil and proslavery factions in Kansas Territory in the mid-19th century. Topeka became the state capital in 1861.

topography Topography is the description or mapping of the physical features of any given area on the Earth's surface. The graphic symbols used to display the features include hachures (parallel lines indicating land-surface variations), contour lines, plastic shading, and color layers. (See MAPS AND MAPMAKING.)

topology Topology, a branch of pure mathematics, deals with the fundamental properties of abstract spaces. Whereas classical geometry is concerned with measurable quantities, such as angle, distance, and area, topology is concerned with notions of continuity and relative position. Point-set topology regards geometrical figures as collections of points, with the entire collection often considered a space. Combinatorial or algebraic topology treats geometrical figures as aggregates of smaller building blocks.

Basic Concepts

In general, topologists study properties of spaces that remain unchanged, no matter how the spaces are bent, stretched, shrunk, or twisted. Such transformations of ideally elastic objects are subject only to the condition that nearby points in one space correspond to nearby points in the transformed version of that space. Because allowed deformations can be carried out by manipulating a rubber sheet, topology is sometimes known as rubber-sheet geometry. In contrast, cutting, then gluing together parts of a space is bound to fuse two or more points and to separate points once close together.

The basic ideas of topology surfaced in the mid-19th century as offshoots of algebra and ANALYTIC GEOMETRY. Now the field is a major mathematical pursuit, with applications ranging from cosmology and particle physics to the geometrical structure of proteins and other molecules of biological interest. Some particular aspects of topology are treated in the articles FOUR-COLOR THEOREM, MÖBIUS STRIP, GROUP THEORY, and TORUS.

In essence the topology of a space provides a way of telling which points are very close to one another and which are not. For instance, it supplies a way of determining whether a curve drawn on a space is continuous (unbroken) or not. However, it does not distinguish between a smooth and a crinkly curve or say anything about the curve's length. Topology does not deal with smoothness or size. Hence, a cube's surface has the same topology as a sphere's surface, even though one has sharp corners and the other is smooth. Such topologically identical figures are termed *homeomorphic*. On the other hand, the surface of a sphere has a different topology from the surface of a torus (doughnut-shaped space).

A primary aim of topology is to find a serviceable set of rules or procedures for recognizing spaces in all dimensions. In such a classification scheme, two spaces would belong to the same topological class if they had the same basic, overall structure although they might differ drastically in their details.

The simplest topological spaces are known as Euclidean spaces. In general the term DIMENSION signifies an independent parameter, or coordinate. A space has *n* dimensions if each of its points is completely determined by *n* independent numbers. An infinitely long line is a one-dimensional Euclidean space. The plane is a two-dimensional Euclidean space. The space of ordinary experience is usually considered a three-dimensional Euclidean space.

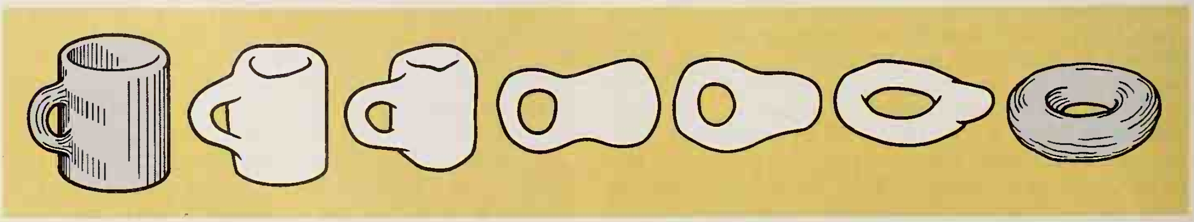
Manifolds

The term *manifold* covers more complicated types than Euclidean spaces. Manifolds locally appear flat, or Euclidean, but on a larger scale may bend and twist into exotic and intricate forms. Any surface, however curved and complicated, so long as it does not intersect itself, can be thought of as consisting of small, two-dimensional, Euclidean patches glued together.

Special manifold characteristics, often expressed as numbers or algebraic expressions known as topological invariants, help distinguish manifolds. Dimension, the number of coordinates required to specify a point in a given space, is one example of a topological invariant. Manifolds may also be either bounded or unbounded. A circle is an example of a bounded, one-dimensional manifold, but a line stretching off indefinitely in both directions is unbounded.

Certain types of two-manifolds, termed *compact surfaces*, can be classified in terms of an invariant called the Euler number. Each different type of compact surface has a particular Euler number. The sphere has Euler number 2; the torus has Euler number 0; the surface of a two-

The surface of a coffee mug is topologically equivalent to the surface of a doughnut. Both are non-Euclidean surfaces that contain exactly one hole, and one can be transformed into the other, through bending or molding, without resorting to cutting or tearing.



Computer-generated images have aided topologists in their efforts to classify knots according to how many times strands of the knots cross each other.

handled soup tureen has a Euler number of –2. Each even integer less than or equal to 2 is the Euler number for exactly one type of closed surface.

A similar idea can be expressed in terms of spheres to which are attached a certain number of handles. The surfaces of a sphere and a lump of clay fall into one group, whereas the surfaces of a doughnut and a coffee mug fall into another. In the latter case, because both forms have one hole, one can imagine smoothly deforming a doughnut-shaped piece of clay to produce a mug with a single handle. On the other hand, there is no way, short of cutting, to turn a spherical balloon into an inner tube.

Topologists, using suitable invariants, can examine in detail what manifolds look like and how one can be transformed into another.

Mathematicians have developed workable schemes for studying manifolds in every dimension except three and four. Dimension three remains a puzzle because proposed classification schemes cover only a portion of all conceivable three-manifolds. Recent research on four-dimensional spaces reveal them to have special characteristics quite unlike those of any other dimension, higher or lower.

The Poincaré conjecture, named for French mathematician Henri POINCARÉ, ranks as one of the most baffling and challenging unsolved problems in algebraic topology. The central idea of homotopy theory (the theory of the relationship between topologically identical spaces) is to reduce topological questions to abstract algebra by associating with topological spaces various algebraic invariants. Poincaré's contribution was the invention of an abstract concept called the fundamental group for distinguishing different categories of two-dimensional surfaces.

Knot Theory

Topology is also concerned with the ways in which one manifold may be embedded within another, such as the ways a knotted circle may be embedded in three-dimensional space. A mathematical knot is the abstract result of first looping and interlacing a piece of string, then joining its ends together. Because any such knot is always topologically equivalent to a circle, the central questions in knot theory concern how that curve is embedded in three-dimensional space.

Knot theorists are particularly interested in identifying when curves are truly knotted, in finding ways of distinguishing different knots, and, more generally, in classifying all possible knots.

To make knot classification easier, investigators examine the two-dimensional shadows cast by the three-dimensional knots. Even the most tangled configuration can be pictured as a continuous loop whose shadow winds across a flat surface, sometimes crossing over, and sometimes crossing under itself.

Torah [tohr'-uh] Torah (a Hebrew word meaning "instruction"), in its broadest sense, refers to the entire body of Jewish teaching incorporated in the Old Testament and the Talmud and in later rabbinical commentaries. In early biblical times, the term meant the oral instruction of the priests on ritual, legal, or moral questions. Gradually the name was applied to written collections of the priestly decisions, most specifically to the written Mosaic law contained in the first five books of the Bible—Genesis, Exodus, Leviticus, Numbers, and Deuteronomy—also called the Pentateuch. The Torah, in the latter sense, is preserved on scrolls kept in the ark of every synagogue.

Tordesillas, Treaty of [tohr-day-seel'-yahs] The Treaty of Tordesillas, concluded on June 7, 1494, decided the rival claims of Spain and Portugal to lands in the New World. After the first voyage of Columbus, Spain secured papal confirmation of its claims to non-Christian lands discovered west of a line of demarcation 100 leagues west of the Cape Verde Islands. Portugal received the lands to the east of this line. JOHN II of Portugal, however, negotiated a treaty with the Spanish, signed at Tordesillas, Spain, moving the line 270 leagues farther west. The shift made possible the successful Portuguese claim to Brazil.

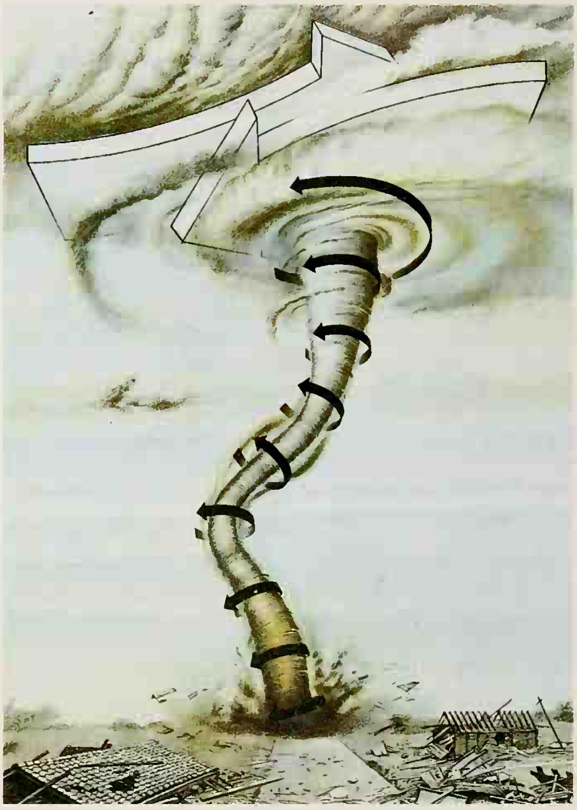
Torelli, Giuseppe [toh-rel'-lee] The Italian violinist and composer Giuseppe Torelli, b. Apr. 22, 1658, d. Feb. 8, 1709, was a pioneer in the development of the concerto grosso and perhaps the originator of the solo violin concerto. He was active in Bologna (1686–95, 1701–09), Ansbach (1697–99), and Vienna (1699–1701). His concerti grossi (published in 1709)—together with those of Arcangelo Corelli—represent, in balance and nobility, the classical ideal of the form. His other works include sinfonias, trio sonatas, and other chamber music for strings.

tornado The word *tornado* is probably derived from the Spanish *tronada* ("thunderstorm"). Tornadoes are also popularly called twisters or cyclones and are characterized by rapidly rotating columns of air hanging from cumulonimbus clouds. They are generally observed as tube- or funnel-shaped clouds. At ground level they usually leave a path of destruction only about 50 m (170 ft) wide and travel an average of only about 8 to 24 km (5 to 15 mi). Contact with the ground is often of an intermittent nature—lasting for a period of usually less than a couple of minutes in any particular area—because the funnel skips along.

Tornadoes generally exhibit a certain characteristic cycle of behavior between formation and final disappearance. The first sign of a tornado may be a strong whirlwind of dust from the ground surface, often in conjunction with the appearance of a short funnel growing from the storm cloud above it. The funnel then becomes more organized and descends further from the cloud, sometimes touching the ground. (The winds forming the funnel generally move counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere, but exceptions are observed.) The funnel as a whole commonly moves forward slowly but can travel at speeds greater than 30 m (100 ft) per second. The tornado eventually becomes fragmented and dissipates.

Causes. Tornadoes are the result of great instability in the atmosphere and are often associated with severe THUNDERSTORMS. The full details of the formation of tornadoes are not known. The existence of a strong updraft, such as that generated by a severe thunderstorm, and the conservation of angular (rotational) momentum, however, are fundamental considerations. The falling of rain or hail probably drags air from aloft, and the resultant inrush of air tightens the rotational motion.

Tornadoes are dark, rapidly rotating funnel-shaped columns of air, water droplets, and dust projecting down from cumulonimbus clouds. The smallest but the most violent of all storms, they usually originate where cold and warm air masses interact and are always associated with severe thunderstorms. High wind speeds, ranging up to 800 km/h (500 mph), and areas of exceedingly low pressure within the tornado's vortex can cause destruction of everything in its ground path.



The tornado proper is inside the tornado cyclone, an area of low pressure about 8 to 24 km (5 to 15 mi) in diameter with wind speeds of approximately 240 km/h (150 mph) or less. The tornado center is an area of exceedingly low pressure. This extreme pressure gradient causes buildings to explode as the tornado effect is felt, if they are not sufficiently ventilated for rapid adjustment to the change in pressure. Wind speeds of approximately 800 km/h (500 mph) have been inferred from the resultant damage.

In the United States, tornadoes are most often associated with conditions in advance of cold fronts, and weather forecasts include tornado alerts when these conditions arise. Tornadoes can occur, however, ahead of warm fronts or even behind cold fronts. Tornadoes also occur frequently in association with hurricanes. WATERSPOUTS are less intense disturbances that originate over a body of water and are not necessarily associated with storm activity. The water in the spout comes from condensation, not from the water below.

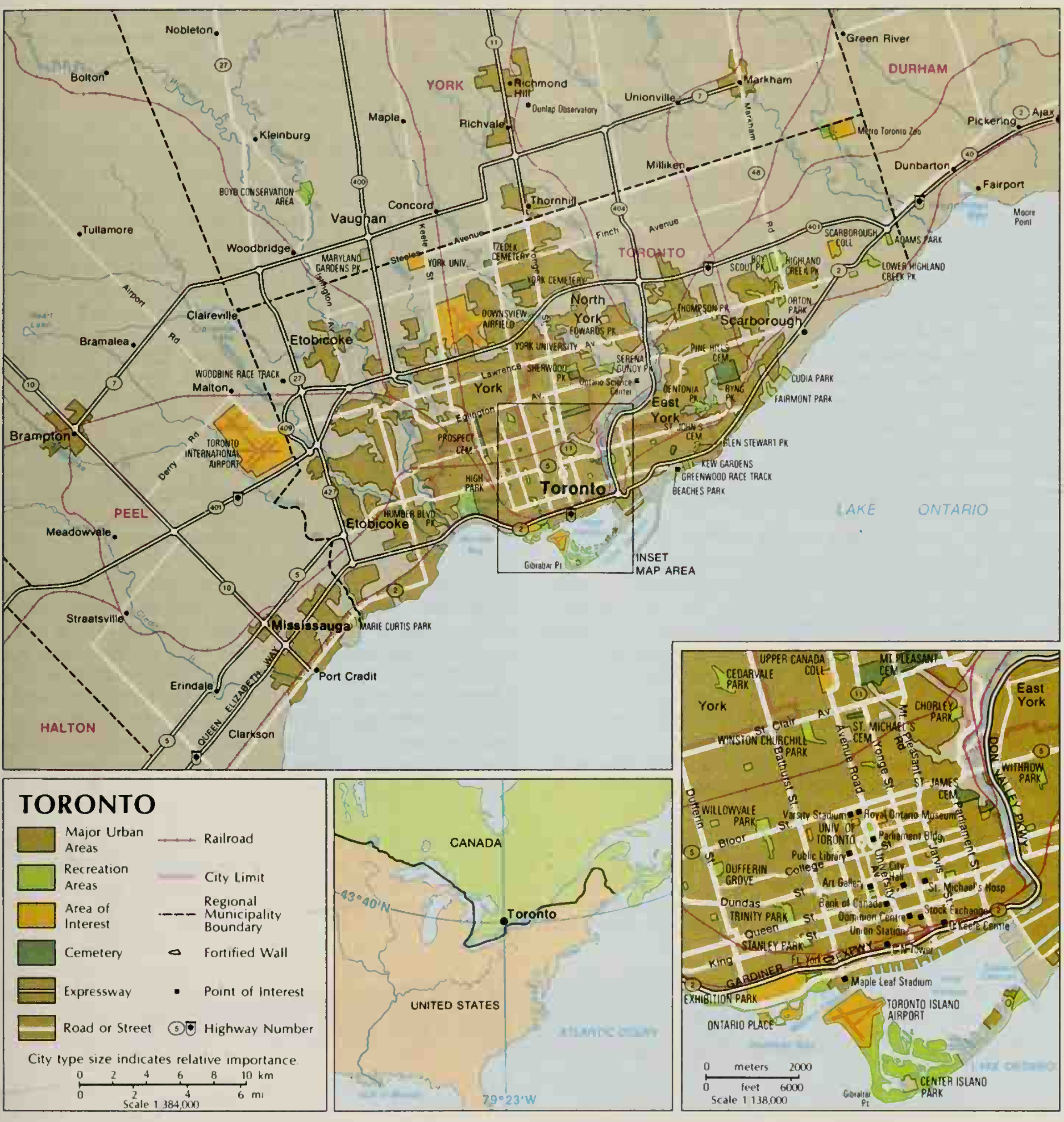
Occurrence. The greatest incidence of tornadoes is generally assumed to be in North America, and especially in the Mississippi Valley. On an equal-area basis, however, countries other than the United States, such as Italy, New Zealand, and the United Kingdom, exceed or at least challenge the U.S. incidence rate. In actual numbers observed, Australia, with about 20 tornadoes annually, ranks second to the United States. The United States is notable for the incidence of severe tornadoes.

Within the United States, Texas records the greatest number, usually about 15 to 20 percent of the nation's annual total of about 1,000. On an area basis, however, Texas ranks ninth, far behind Oklahoma, Kansas, and Massachusetts. A rather steady increase in the annual total has been observed. The seasonal maximum occurs in the spring and early summer, although tornadoes have been reported in all months. The height of the tornado activity is in early spring in the southern United States, later across the more northerly regions, and in July in western Canada.

See also: CYCLONE AND ANTICYCLONE; WEATHER FORECASTING.

Toronto The City of Toronto, with a population of 612,289 (1986), is the core segment of the Municipality of Metropolitan Toronto. The latter, consisting of five cities and one suburban borough, has a population of 2,192,721 (1986). Located on the shore of Lake Ontario, Toronto is the capital of Ontario and a leading financial, industrial, and cultural center.

Contemporary City. For most of its history Toronto's population was composed principally of persons of British descent. After World War II an influx of immigrants from continental Europe and Asia began. Since then the city has absorbed a third of all the postwar immigrants to



Canada, making it one of the most cosmopolitan cities in North America. The largest single ethnic group in metropolitan Toronto is still composed of persons of British origin, but there are also sizable numbers of Italian, German, French, Asian, Ukrainian, Polish, Dutch, and Scandinavian persons.

Toronto's economic development has benefited from the city's location on the Great Lakes, and its role as an inland port greatly increased with completion (1959) of the St. Lawrence Seaway. The city is also the focus of Canada's major railroad lines. Toronto is considered Canada's industrial hub. Its principal products are textiles; wood products; fabricated metals, machinery, and electrical apparatus; transportation equipment; and chemicals. Food processing, particularly meat packing, is a growing industry. Most of Canada's leading book and magazine publishers, as well as the country's two largest daily newspapers—the *Toronto Globe and Mail* and *Toronto*

Star—are located there. The city is a major financial center, and its stock exchange is one of North America's most active. Much of the retail activity is concentrated on Yonge Street.

Toronto's downtown area has experienced massive and rapid new construction. Among the buildings of major architectural distinction are Viljo Revell's new City Hall, Mies van der Rohe's Dominion Centre, and I. M. Pei's Commerce Court West. The 553-m-high (1,815-ft) CN Tower is the world's tallest freestanding structure. Ontario Place, a complex of artificial islands next to the waterfront—adjacent to the grounds of the Canadian National Exhibition—provides theaters, as well as restaurants and marinas. The professional sports teams are the Maple Leafs (hockey), Blue Jays (baseball), and Argonauts (football).

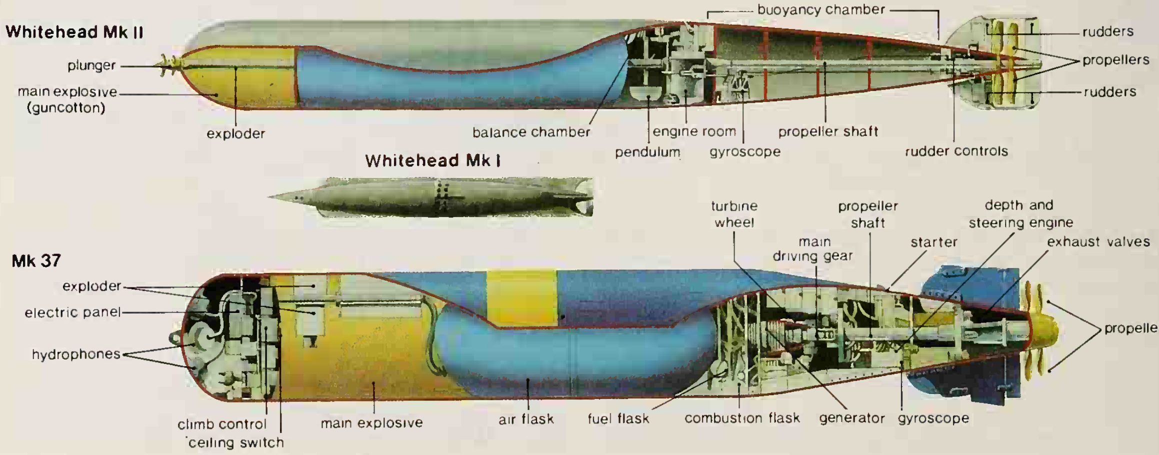
Toronto's largest and most modern theaters are the O'Keefe Centre for the Performing Arts—home of the National Ballet of Canada—and the St. Lawrence Centre for the Performing Arts. The Toronto Symphony performs in the striking Roy Thomson Hall, opened in 1982. The University of Toronto (1827) and York University (1959) are major institutions. The Royal Ontario Museum is part of the University of Toronto.

History. The first white man to visit (1615) the site of the future city of Toronto was the French explorer Étienne Brûlé. In 1720 the French established a small trading post there and called it Fort Toronto. (The name *Toronto* is said to have been derived from an Indian term meaning "place of meeting.") In 1750 a new and larger Fort Rouillé was built. In 1759, however, the French burned Fort Rouillé to prevent it from falling into the hands of the British. So ended the French regime at Toronto. In 1793 the British established a settlement there named York, which became the capital of Upper Canada (Ontario). Only in 1834, when it was incorporated as a city, did Toronto regain its original name. With the arrival of railroads (1850s), Toronto experienced rapid economic growth. In 1953 the creation of the Metropolitan Toronto Corporation introduced regional government.

Toronto, University of Established in 1827, the University of Toronto is a coeducational institution in Toronto, Ontario. It has faculties of arts and sciences, music, education, architecture, medicine, dentistry, nursing, engineering, forestry, and library science, all with undergraduate and graduate programs. Federated universities are the University of Trinity College (1851), Victoria University (1890), and the University of Saint Michael's College (1852). Liberal arts colleges of the University of Toronto are Erindale (1964), Innis (1964), New (1962), Scarborough (1964), University (1853), and Woodsworth (1974). Federated theological colleges are Emmanuel (1928, United Church of Canada), Knox (1844, Presbyterian), and Wycliffe (1877, Anglican). Among the university's facilities are the Centre for Russian and East European Studies and the Institute for Aerospace Studies. The university is the controlling body of the Royal Conservatory of Music and the Royal Ontario Museum.

torpedo A modern torpedo is a large, cigar-shaped, self-propelled, underwater projectile that can be launched from aircraft and both surface and subsurface ships (see NAVAL VESSELS) against surface and submersible targets. Until the post–Civil War era, the term *torpedo* was used to designate many forms of moored or fixed mines. One naval version, the spar torpedo, consisted of a charge fixed to the end of a pole (spar), which detonated on contact with the target.

The torpedo designed by British engineer Robert Whitehead (Whitehead Mk I, center) *was first used in 1868 by the Austrian navy. Powered by a compressed-air engine, it traveled at a speed of about 7 knots (13 km/h; 8 mph), had a range of 600 m (1,969 ft), and carried a charge of guncotton. By the mid-1890s it had evolved into the more sophisticated Mk II* (top), *which carried a 45- to 180-kg (110- to 400-lb) charge of guncotton and had a steering mechanism controlled by a gyroscope. The U.S. Navy's MK 37* (bottom), *used in several different versions since 1957, carries 150 kg (330 lb) of high explosives in its warhead and an automatic homing system that employs hydrophones to detect sounds made by the target ship.*



The father of the modern torpedo was the British engineer Robert Whitehead, who demonstrated the first self-propelled torpedo in 1866. In 1895, an Austrian, Ludwig Obry, adapted the gyroscope to provide the torpedo with reliable directional control, a development that permitted ships to fire their torpedoes at targets not in line with the direction of launch. More modern developments include steam power, electric drive, a complex family of homing devices, and missile-delivered torpedoes.

Contemporary torpedoes consist of four major components, which are, from front to rear, a warhead, a fuel section, an afterbody, and a tail section. The warhead includes the explosive charge, an exploding mechanism, and, in the case of homing torpedoes, the homing device, which is normally mounted forward of the actual warhead. The fuel section contains the batteries of an electric torpedo or compressed air, water, and fuel for steam torpedoes. The afterbody encloses the propulsion motor, its gear box, the gyroscope, and the depth-regulating mechanism. The tail section encloses the propeller shaft and supports the external tail blades and their individual rudders and elevators. The propeller or propellers are mounted at the extreme end of the torpedo, immediately behind the rudders and elevators.

Torpedo guidance systems now in use include wire guidance, programmed search, acoustic, and active and passive sonar. Wire guidance is used for short ranges and allows control commands to be transmitted from the launcher by way of wires to the torpedo during its run. Programmed search is the result of commands initiated by systems within the torpedo. Acoustic torpedoes are guided to the target by the noise (cavitation) of the target's screws. SONAR signals can be generated from the torpedo (active) or triggered by the target's noise (passive).

The U.S. Mk 48, reportedly the most complex torpedo in existence, can dive 914 m (3,000 ft), has a range of 46 km (28.5 mi), and has a speed of 93 km/h (57.8 mph).

torque [tohrk] Torque in rotational motion corresponds to force in linear motion. It is the product of the force tending to rotate an object, multiplied by the perpendicular radius arm through which the force acts (see STATICS). The net torque on an object is proportional to the resulting change in angular momentum. Torque is a vector directed along the rotational axis. If the fingers of the right hand curl in the direction of the change of rotation, the extended thumb points in the direction of the torque.

Torquemada, Tomás de [tohr-kay-mah'-dah] Tomás de Torquemada, b. 1420, d. Sept. 16, 1498, grand inquisitor of the Spanish INQUISITION, has come to symbolize religious fanaticism and persecution. He studied in Valladolid, joined (1434) the Dominicans, served (1452–74) as prior of the Monastery of Santa Cruz in Segovia, and became (1474) confessor and advisor to the "Catholic kings"—Isabella I and Ferdinand II. Although he was probably of Jewish descent, Torquemada instigated attacks on orthodox Jews and Marranos (Jews who had nominally converted to Christianity). An inquisition was established to deal with this matter in 1478, and in 1483, Torquemada was made grand inquisitor.

Torquemada pushed vigorously the prosecution of Jews, apostates, witches, crypto-Jews, and other spiritual "offenders." Two thousand died and many more were tortured under his authorization. Under his influence, Ferdinand and Isabella expelled (1492) from Spain all Jews who had not converted—more than 160,000 people.

Torrens system The Torrens system, which was invented in 1858 by the Australian statesman Sir Robert Torrens (1814–84), is a system guaranteeing land TITLES and assuring owners that their rights to property will not be challenged. The Torrens system was first used in Australia and was also introduced into other parts of the British Commonwealth. In the rapidly growing United States of the 19th century, hundreds of thousands of deeds, mortgages, and land contracts were deposited in public record offices, which were little more than storehouses with indexes.

Under the Torrens system that went into effect in an optional form in Illinois in 1897, a land title is traced back to the original grant (from an English or Spanish king or from the federal or state government), and all questions as to its validity are cleared up. After this exhaustive scrutiny, the title is, in effect, insured by the state. Unfortunately, the high cost of a Torrens search has limited its use and effectiveness.

Torreón [toh-ray-ohn'] Torreón (1980 pop., 328,086), a city in southwestern Coahuila state, north central Mexico, lies 315 km (195 mi) west of Monterrey. It is a milling center for the cotton and wheat grown nearby. In addition, the city has a smelter for silver, zinc, copper, and lead mined in the vicinity.

One of the newest Mexican cities, Torreón was founded in 1893 as a railroad junction. It remained underdeveloped until the formation (1936) of Laguna District, a state-sponsored agricultural irrigation cooperative for cotton growing.

Torres Strait [tohr'-uhs] The Torres Strait separates Australia from New Guinea and links the Coral and Arafura seas. About 150 km (95 mi) wide and dotted with volcanic islands and coral reefs, the strait is used for local shipping and pearl diving. The first European to sail through it was the Spaniard Luis Váez de Torres in 1606.

Torreya [tohr'-ee-yuh] *Torreya* is a genus representing six species of trees and shrubs in the yew family, Taxaceae. Native to localized areas of China, Japan, and North America, these plants are handsome evergreens but little known in cultivation. Leaves are flattened needles arranged in two ranks with two sunken waxy-appearing bands paralleling the midrib. Stinking cedar, *T. taxifolia,* which may be found in Florida, emits a putrid or fetid odor when bruised.

Torricelli, Evangelista [tohr-ee-chel'-lee] The Italian mathematician and physicist Evangelista Torricelli, b. Oct. 15, 1608, d. Oct. 25, 1647, proposed (1643) an experiment that demonstrated that atmospheric pressure determines the height to which a fluid will rise in a tube inverted over a saucer of the same liquid. This concept led to the development of the barometer. Torricelli—who served (1641–42) as Galileo's secretary and succeeded him as the court mathematician and philosopher to Grand Duke Ferdinando II of Tuscany—also proved that the flow of liquid through an opening is proportional to the square root of the height of the liquid (Torricelli's theorem).

Torrijos Herrera, Omar [tohr-ee'-hohs hay-ray'-rah] Brig. Gen. Omar Torrijos Herrera, b. Feb. 13, 1929, dominated Panama from 1968 until his death in a plane crash on July 31, 1981. A career soldier, he led the coup that overthrew President Arnulfo Arias in 1968 and became formal chief of state in 1972. He successfully negotiated the Panama Canal treaties of 1978 with U.S. president Jimmy Carter. In 1978, Torrijos resigned as chief of state, and Aristides Royo, a close political ally, was elected president. As head of the National Guard, Torrijos remained the most powerful person in the country.

Torstenson, Lennart [tohr'-stuhn-sohn] The Swedish field marshal Lennart Torstenson, b. Aug. 17, 1603, d. Apr. 7, 1651, was the greatest artillery officer of the THIRTY YEARS' WAR. He became commander of the Swedish field artillery in 1630 and shared in the great victories of King GUSTAV II ADOLF. He became chief of staff under Johan Banér in 1635 and then commander of the Swedish army in 1641. Torstenson won a major victory over the imperial army at the second Battle of Breitenfeld (1642), and his lightning attacks on Moravia (1642, 1643), Denmark (1643–44), and Bohemia (1645) became legendary. After retiring in 1646, Torstenson was a supporter of Queen CHRISTINA's policies.

tort [tohrt] Torts are a group of civil wrongs that in some way bring injury to persons or property and for which the law provides a remedy in the form of an award of a sum of money (money damages). The term *civil wrong* refers to the fact that a suit based on tort is not prosecuted by the state in a criminal proceeding but rather is initiated by a private party acting as the plaintiff. Tort suits are distinguished from those in CONTRACT, in that a contract is based on an agreement of the parties, whereas a tort is inflicted without the consent and over the objection of the complaining party. Torts are a diverse group of wrongful acts; some of the more important are ASSAULT AND BATTERY, libel and slander (see DEFAMATION), NEGLIGENCE, TRESPASS, false imprisonment, and malicious prosecution.

The origins of tort go back nearly 700 years, almost to the dawn of the English COMMON LAW. Originally the functions of CRIMINAL LAW—which today provide for a government's punishing for wrongful conduct—and of tort law—which provide for a private party securing reimbursement for certain wrongs—were not distinguished from one another. These have gradually become two clearly separate areas of law, but even today some laypersons may find them confusing because the same act—striking another, for example—may give rise to suits both in criminal law and in tort. The government has a duty to maintain public order and may therefore prosecute and punish wrongful conduct; yet a party injured by the wrongful act is not compensated for the wrong by the criminal prosecution and may therefore sue in tort to recover money damages for the same act.

In earlier times torts were divided according to injury direct (termed *trespass*) or indirect (termed *trespass on the case*). Within the past 150 years this distinction has been abandoned, and the primary line of distinction is now based on whether the tort is intentional (for instance, battery, assault, false imprisonment, and malicious prosecution) or negligent (the tort of negligence). These torts will be discussed below, along with torts that are not classified according to the presence or absence of intent (for instance, defamation, trespass, and conversion).

Intentional Torts

Battery. Battery consists of any intentional, unpermitted contact inflicted upon another. For intent to be found, it is sufficient if the defendant should have realized the act would probably cause an unpermitted contact, as when he or she throws a brick out the window into the midst of a crowd. The actual contact is ordinarily obvious, as when a person strikes another with fists or a club, but could include shooting, administering poison secretly, or any other form of contact not consented to by the victim.

Assault. An assault is essentially an offer, attempt, or threat to commit battery. The tort arises only when the perpetrator has the present apparent ability to carry out the battery. Making a threatening phone call would not constitute an assault because the *present* apparent ability to carry out the battery is lacking. In fact, mere words do not constitute an assault. Some motion or gesture must be made suggesting that a battery is actually about to take place. Assault, like battery, requires an intent.

False Imprisonment. Any intentional, unlawful total restraint will constitute false imprisonment. Intent to restrain is essential, but restraint need not amount to a physical confinement. A party ordered to remain in a store, under threat of physical abuse, while a clerk sends for police, is being restrained. Whether this act amounts to false imprisonment depends on whether the restraint was legally justified under the circumstances. Although intent to restrain is essential to this tort, motive is irrelevant.

False arrest is a subcategory of false imprisonment. The term *false arrest* is applied when the restraint is imposed under pretense of legal authority that is actually lacking. Police may be held liable for false arrest when they arrest without the necessary legal authority. Merely arresting a party who subsequently is found not guilty of the crime does not constitute false arrest.

Malicious Prosecution. Malicious prosecution is the remedy for instituting—with the intent to injure or harm—criminal proceedings against the plaintiff. To prove a case in malicious prosecution, the plaintiff must show that he or she was charged with a crime at the malicious instigation of the defendant, was tried, and found not guilty.

Negligence

The rationale behind the tort of negligence is that even though an injury may not have been intentional, it nonetheless may be blameworthy because the defendant did not use reasonable care under the circumstances. On the other hand, before negligence may be found, some wrongful act or omission on the part of the defendant has to have been made.

The technical requirements for a suit in negligence are a duty to exercise care, a breach of that duty, and a proximate cause between the breach of the duty and an injury to the plaintiff.

Usually a duty exists to avoid injuring others, but exceptions occur. An individual is usually not under a legal duty to maintain land and buildings so that unexpected trespassers will be safe. In some instances courts have found no duty on the basis that the defendant could not possibly have foreseen that his or her act would endanger the plaintiff. In most negligence cases, however, the duty of the defendant to avoid injuring the plaintiff is reasonably clear. Whether or not the defendant has performed this duty is largely a jury question.

Even if the defendant is found not to have acted as a reasonably prudent person, he or she is liable for the tort of negligence only if a fairly close cause-and-effect relationship exists between the careless conduct and the subsequent injury. This cause-and-effect relationship is what is meant by the term *proximate cause*.

The final requirement for a negligence suit is that the plaintiff be injured. The injury may be to person or property, but if to person, the injury must be caused by at least some impact. Most cases do not allow damages for purely mental distress. (A new tort category of intentional infliction of mental suffering, however, has gained increasing recognition in recent years.) After concluding that the defendant was liable for the plaintiff's injury, the jury determines a specific sum that will fairly compensate the plaintiff and awards this as money damages.

Other Torts

Defamation. Injury to reputation is protected by the tort of defamation, which is really two closely related torts, libel and slander. Libel consists of written or permanently recorded injuries to reputation; slander consists of oral injuries.

The first requirement of defamation is an injurious statement, usually in writing in the case of libel and oral in the case of slander. The statement must be one that would expose the plaintiff to hatred, contempt, or ridicule; that is, it must seriously affect reputation. The statement must be transmitted to at least one person other than the defamer and the defamed, and the statement must be false. In cases in which the truth of the statement is contested, the defendant may be found liable unless he or she can prove truth.

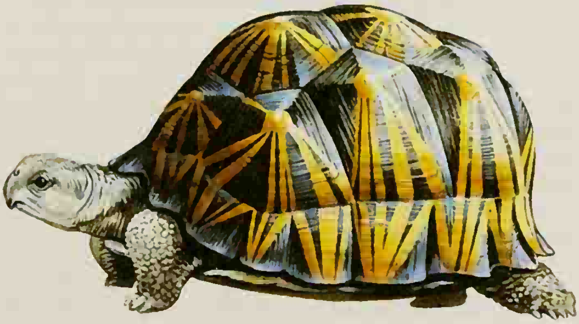
A number of instances occur in which a party is given a legal right to make statements that would otherwise be defamation. This right to be exempted from libel or slander suits is called privilege. Legislators, high executive officials, and judges have an absolute, or unlimited, privilege when conducting official business. The same holds true of communications between husband and wife. A number of other instances exist in which privilege is available, as long as the statement was not made with malice (that is, knowing it to be false or in reckless disregard to whether it is true or false). This is termed qualified privilege. Qualified privilege is available in commenting on public officials, on the work of public figures such as entertainers, and in a number of other instances of minor importance.

Trespass. Trespass provides protection for interests in real property (land or buildings) and will offer a remedy for any entry of a thing or person upon the real property possessed by another. Although the traditional rule was that trespass would be found even in the case of accidental or unintended entry onto the land of another, the more modern rule is that liability will be found only in the event of intentional or negligent entry or while carrying on especially hazardous activities.

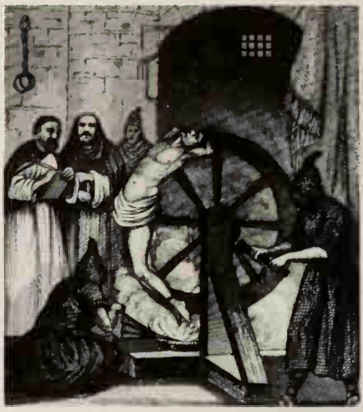
Conversion. Conversion provides a remedy for interference in rights to personal property (in other words, any movable property, as distinguished from real property). Acts such as wrongfully acquiring possession of, transferring, withholding, or damaging the personal property of another constitutes conversion. The remedy for conversion is a forced sale; that is, the defendant is required to pay the plaintiff the value of the converted property, and the defendant then is given the property.

tortoise Tortoises are terrestrial TURTLES having short, elephantlike feet with unwebbed toes. They are found primarily in dry areas. Sometimes called "land turtles," the

The radiated tortoise of Madagascar bears radiating patterns on its shell. It has been overexploited for its edible meat.



more than 40 species of tortoises, family Testudinidae, are found in all temperate and tropical areas except Australia and Polynesia. They range in size from about 15 cm (6 in) to more than 90 cm (3 ft), usually have a high-domed shell, and can draw the head completely in under the shell. They are generally slow-moving, plant-eating, and long-lived. The largest species, some reaching 230 kg (500 lb)—genus *Testudo*—are found on the Galápagos Islands off Ecuador in the Pacific and on some Indian Ocean islands. Four species of gopher tortoises (genus *Gopherus*), found in the southern United States and northern Mexico, are known for their burrowing habits. Other species, genera *Testudo* and *Geochelone*, are found across southern Europe and Asia and in South America. Some species (genus *Kinixys*) have hinged upper shells, and others (genus *Malacochersus*) possess flat and pancakelike shells.


A medieval heretic is broken on the wheel. This method of torture, which stretched and dislocated joints of the body, was one of the devices used by the Inquisition to extract confessions of heresy or witchcraft or to obtain accusations against others suspected of such practices.

torture Torture is the deliberate infliction of pain by one person on another. Universal methods of physical torture include beatings, electric shocks, and prolonged hanging by the arms or the feet; the injection of drugs can cause psychic as well as physical pain. The essential features of torture are that at least two persons are involved; the perpetrator has physical control over the victim; and the torture is purposeful and systematic. Its purpose is to break the will of the victim and to dehumanize him or her; the intent may be to punish, to obtain information, to extract a confession from the victim or a third party, or to intimidate the victim or others.

Torture has been widely used for at least 2,000 years. It was part of the legal process in both ancient Greece and Rome. Early Greek and Roman laws specified that only slaves might be tortured, but, later, freemen could be tortured in cases of treason. It was the right of a master to offer his slaves for torture in order to prove his own innocence or to discipline them. In the Middle Ages, torture was routine in proceedings of the INQUISITION. In colonial America, "witches" were tortured by dunkings and other punishments to prove their guilt or to make them recant their beliefs.

A movement in Europe to abolish torture began about 1750 and continued through the 19th century. During the Age of Enlightenment, opposition to torture was based on both humanitarianism and the legal theory that torture is not necessary to produce evidence for conviction.

The first European countries to abolish torture entirely were Sweden and Prussia. In France the NAPOLEONIC CODE forbade torture as part of the legal process and served as a model of statutory reform throughout Europe. The 5th Amendment to the U.S. Constitution (prohibiting self-incrimination) and the 8th Amendment (prohibiting cruel and unusual punishment) effectively outlaw torture in the United States.

Torture has been resurgent in the 20th century. Nazi Germany brought back torture vengefully in its concentration and death camps, as did Soviet dictator Joseph Stalin in the GULAG system and, more recently, the Pol Pot regime in Cambodia. German physicians were involved in both the development and the use of torture instruments. Soviet psychiatrists also adapted their specialty to this purpose by the abuse of psychoactive drugs and forced commitment of dissidents.

In the 1980s torture was officially sanctioned in approximately 70 nations, though it was not legal anywhere. The most notable systematic users of torture include authoritarian countries and police states in which power is concentrated in the hands of one or only a few persons.

The United Nations in 1984 adopted the Convention against Torture and Other Cruel, Inhuman, or Degrading Treatment or Punishment, which obliges states to make torture a punishable offense and provides for the extradition of torturers and the compensation of victims.

torus [tohr'-us] A *torus,* or *anchor ring,* is the mathematical name for the shape of such common objects as doughnuts, hoops, rings, and tires (see TOPOLOGY). It is defined as the solid generated by the revolution of a circle about an axis that is in the plane of the circle but does not intersect the circle itself. If the radius of the circle is r and the center of the circle is a distance k from the axis, then the torus will have surface area $4\pi^2kr$ and volume $2\pi^2kr^2$.

Tory party The Tory party of England, which dates from 1679, consisted originally of loyal supporters of the Church of England and of the king, who preferred, at most, only gradual constitutional and social reforms. When King CHARLES II was asked to call a Parliament in 1679 to exclude his Roman Catholic brother (later King JAMES II) from the succession, his supporters were nicknamed Tories, a name for Irish outlaws.

The Tory party gave its support to Charles II and James II, was generally favored by King WILLIAM III and was responsible for obtaining the Peace of Utrecht under Queen Anne. The party then split between the Whimsical Tories, who favored a Protestant successor to the queen, and the Jacobite Tories (see JACOBITES), who wanted to put James II's eldest son, a Roman Catholic, on the throne.

A second Tory party came into existence under William PITT the Younger, who was prime minister between 1783 and 1806. After the Napoleonic Wars the conservative duke of WELLINGTON led the party, but its opposition to the first parliamentary Reform Bill proved disastrous. In the 1830s the Tory leader Sir Robert PEEL urged a more moderate party stance, but when he repealed (1846) the protectionist CORN LAWS, he was considered to have betrayed Tory principles. His followers, the Peelites, subsequently coalesced with the Whigs (who were evolving into the Liberal party), and it was left to Benjamin Disraeli, who opposed Peel, to transform the Tories into the CONSERVATIVE PARTY. In American usage the term was applied to Loyalists during the American Revolution.

Tosca see PUCCINI, GIACOMO

Toscanini, Arturo [tohs-kah-nee'-nee] The Italian conductor Arturo Toscanini, b. Mar. 25, 1867, d. Jan. 16, 1957, was among the most admired musicians of his time. After graduating (1885) with honors from the conservatory in his native Parma, he was engaged as cellist and coach by an opera company bound for Brazil. When, in Rio de Janeiro, the troupe's conductor walked out, Toscanini stepped in, leading Verdi's *Aïda* without a score (1886). Returning to Italy, he was in the orchestra for the first performance of Verdi's *Otello* (1887) and led the premieres of Leoncavallo's *Pagliacci* (1892) and Puccini's *La Bohème* (1896). In 1898 he became chief conductor at La Scala, Milan. In 1908 he commenced a 7-year tenure at the Metropolitan Opera in New York City. Subsequently, he was principal conductor of the New York Philharmonic (1928–36) and of the NBC Symphony, created for him in 1937 and disbanded on his retirement in 1954. He was a welcome visitor to London and was acclaimed at the Bayreuth and Salzburg festivals, where later, in protest against Nazism, he refused to appear.

Although Toscanini conducted some 20th-century works, including those of Stravinsky, his core repertoire consisted of the operas of Verdi and Wagner and the symphonies of Beethoven and Brahms. His rehearsal tantrums were legendary, but he won the affection of his musicians, from whom he could command playing of astonishing unanimity, energy, and clarity. One of the great cult figures of his time, Toscanini became the incarnation of music for a vast audience.

Arturo Toscanini, one of the world's greatest conductors, demonstrated his remarkable abilities when he substituted in a performance of Verdi's Aïda, *conducting from memory at the age of 19. As director of many of the world's great orchestras, he elicited exhilarating virtuoso performances.*

totalitarianism Totalitarianism is a form of government in which all societal resources are monopolized by the state in an effort to penetrate and control all aspects of public and private life. This control is facilitated by propaganda and by advances in technology. Two types of totalitarianism may be distinguished: NAZISM and FASCISM on the right and COMMUNISM on the left.

Both in theory and practice, totalitarianism is of relatively recent origin. First used to describe the organizational principles of the National Socialist (Nazi) party in Germany, the term gained currency in political analysis after World War II. Older concepts, such as DICTATORSHIP and DESPOTISM, were deemed inadequate by Western social scientists to describe this modern phenomenon.

Totalitarian regimes are characterized by distinctive types of ideology and organization. Totalitarian ideologies reject existing society as corrupt, immoral, and beyond reform, project an alternative society in which these wrongs are to be redressed, and provide plans and programs for realizing the alternative order. These ideologies, supported by propaganda campaigns, demand total conformity on the part of the people.

Totalitarian forms of organization enforce this demand for conformity. Totalitarian societies are rigid hierarchies dominated by one political party and usually by a single leader. The party penetrates the entire country through regional, provincial, local, and "primary" (party-cell) organization. Youth, professional, cultural, and sports groups supplement the party's political control. A paramilitary secret police ensures compliance. Information and ideas are effectively organized through the control of television, radio, the press, and education at all levels.

In short, totalitarian regimes seek to dominate all aspects of national life. In this respect totalitarianism differs from older concepts of dictatorship or tyranny, which seek limited—typically political—control. In addition, totalitarian regimes mobilize and make use of mass political participation, whereas dictatorships seek only pacified and submissive populations. Finally, totalitarian regimes seek the complete reconstruction of the individual and society; dictatorships attempt simply to rule over the individual and society.

totem A totem is an animal, plant, object, or natural phenomenon associated with a social or kinship group and toward which that group may adopt a ritual attitude. The term *totemism* has been applied to a great diversity of beliefs and practices found among various preliterate cultures. The classic example of totemism would be a society in which there are a number of subgroups, such as CLANS, each one of which has a special relationship with a particular kind of animal. Often the clan has the totem's name,

Carved and painted totem poles, such as these in an Indian village near Vancouver, British Columbia, are created by a number of North American Indian peoples of the Pacific Northwest. The plant and animal totems, depicted in familiar, standardized forms, have traditionally symbolized ancestral spirits and are often associated with particular legends documenting each clan or tribe's lineage and social position.

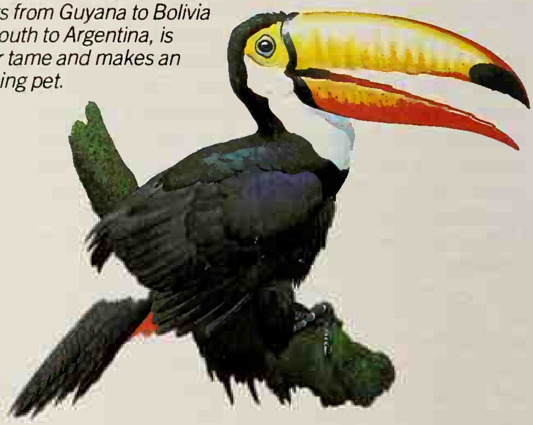
and its members are conceived of as being related to the totem through mythical ancestry. If the totem is an animal, clan members typically will abstain from eating it, and the well-being and increase of the totem animal will be the purpose of clan rituals. Among variations are sexual totemism, in which the totem is identified collectively with the members of either sex, and individual totemism, in which a sorcerer is thought to have gained the assistance of an animal species. The Ojibwa Indians of North America, from whose language the word *totem* is derived, have clans named for fish, mammals, and birds but without connected dietary restrictions and with little ritual.

Many interpretations of totemism have been offered. The sociologist Émile Durkheim saw in the relation to the totem a symbolic expression of the sentiments of attachment to the group; he interpreted this as an elementary form of religion (see PRIMITIVE RELIGION). The anthropologist Claude Lévi-Strauss has suggested that totemism reflects a kind of logic in which the differences between species and kinds in the natural world are used to express the categorization of society.

The massive carved posts—the so-called totem poles—of such Northwest Coast Indians as the Haida, Tlingit, and Tsimshian were traditionally erected to memorialize important events, to mark land ownership, or as monuments to the dead. Their carvings concern family histories and show ancestors along with the spirits—in animal or human form—that aided them (see INDIANS OF NORTH AMERICA, ART OF THE).

toucan [too'-kan] Toucans are boldly marked arboreal birds that have very large, serrated, and often multicolored bills that may exceed the birds' body length. About 37 species, making up the family Ramphastidae, are found from sea level to about 3,000 m (10,000 ft) in woody regions of Central America and tropical South America. Toucans commonly have a body length of 30 to 60 cm (1 to 2 ft), short and rounded wings, and strong legs with two toes oriented forward and two backward. The tongue has a featherlike fringe along each edge. The beak and plumage are usually brightly colored. Toucans are often gregarious and noisy. Most feed mainly on small fruits. They typically nest in tree cavities, where both parents incubate the eggs and care for the young. The largest toucans and those with the largest bills—genus *Ramphastos*—generally have black plumage offset by brightly colored throats, breast spots, and feathers above and below the tail. The 11 species of aracaris, genus *Pteroglossus,* are black or dark green above and lighter below, often with scarlet patches.

The toco toucan, found in rain forests from Guyana to Bolivia and south to Argentina, is rather tame and makes an amusing pet.



touch see SENSES AND SENSATION

Toulon [too-lohn'] Toulon, a commercial and industrial city in southeastern France, lies on the Mediterranean Sea about 50 km (30 mi) east of Marseille. The population is 179,423 (1982). Toulon's harbor serves as the primary naval base of the French Mediterranean fleet. The city's economy is based on shipbuilding, engineering industries, petroleum refining, wine making, food processing, tanning, the production of chemicals and furniture, and tourism.

Toulon, or Telo Martius as it was then known, served as a naval station for the Romans. Acquired by the French crown in 1481, Toulon was developed as a port by Henry IV (r. 1589–1610) and enlarged and fortified by Cardinal Richelieu and Sébastien Le Prestre de Vauban in the 17th century. The English captured Toulon in 1793, but the French recaptured it a year later in a battle in which Napoléon Bonaparte became a hero. During World War II much of the French fleet was scuttled in Toulon's harbor in November 1942 to prevent its seizure by the Germans.

A submarine base during the German occupation, Toulon suffered heavy Allied bombing in 1943 and 1944. It was retaken by the French in August 1944.

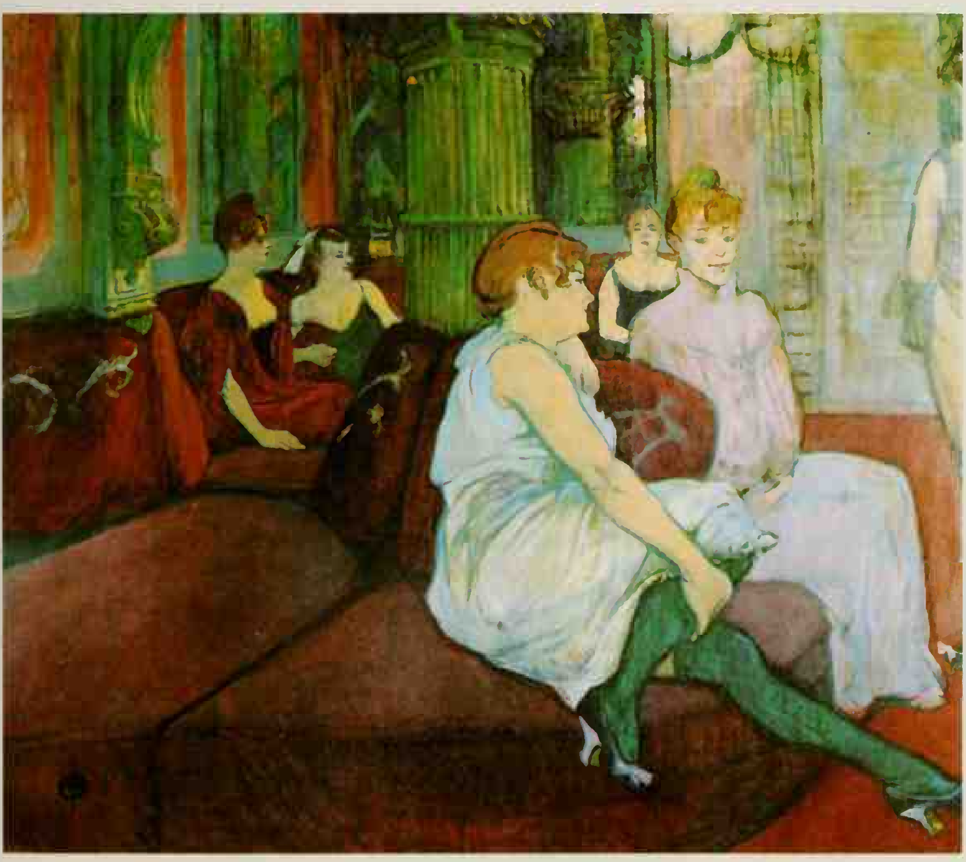
Toulouse [too-looz'] Toulouse is a major city in southern France, on the east bank of the Garonne River, about 600 km (370 mi) south of Paris. The population is 359,000 (1990). Canals connect Toulouse to the Atlantic and the Mediterranean.

After World War II, Toulouse became a center of the French aerospace industry and associated production of electronics and chemicals. The older established manufactures are leather, shoes, textiles, stained glass, and machinery. Historic landmarks include the Romanesque Basilica of Saint-Sernin (11th–12th century) and the Gothic Cathedral of Saint-Étienne, begun during the 11th century. The University of Toulouse (1229) is the second oldest university in France.

Toulouse, known as Tolosa, was an important Gallic city when it was taken by the Romans in 106 BC. Later it was the capital (AD 419–507) of the Visigothic kingdom of Toulouse. From the 9th century Toulouse was the seat of a powerful county and the center of the distinctive LANGUEDOC culture. In the 13th century, after the crusade against the ALBIGENSES, the county was annexed to the French crown. The city, however, enjoyed virtual autonomy until 1790. The British defeated the French at Toulouse in 1814. During World War II, Toulouse was occupied by the Germans from 1942 to 1944 and suffered considerable damage.

Toulouse-Lautrec, Henri de [too-looz'-loh-trek'] Henri Marie Raymond de Toulouse-Lautrec, b. Albi, France, Nov. 24, 1864, d. Sept. 9, 1901, was a leading postimpressionist artist whose paintings, lithography, and posters contributed much to the development of ART NOUVEAU in the 1890s. He was also a harsh and witty chronicler of the gaudy nightlife and the sordid elements of late-19th-century Parisian society. Two falls (1878–79), abetted by bone disease, resulted in crippling injuries to his legs, which thereafter remained stunted. A grotesque-looking cripple, with the legs of a boy and the torso of a young man, he concentrated on observing and drawing, rather than participating in, social activities.

About 1883, Toulouse-Lautrec befriended such other avant-garde artists as Vincent van Gogh. Dating from this time are several psychologically penetrating portraits, which show in their color and brushwork his absorption of



At the Salon of the Rue des Moulins *(1894) is one of a series of Parisian brothel scenes painted by Henri de Toulouse-Lautrec beginning in 1892. Typical of his mature style is the angular, off-center composition. Bathed in harsh, theatrical light, the prim madam sits upright, surrounded by the casually dressed women waiting for customers. Lautrec, unrelentingly honest in his portrayal, also conveys without sentimentality a sense of their life's meaningless boredom. (Musée Toulouse-Lautrec, Albi, France.)*

impressionism. In the later 1880s he was influenced by Japanese prints, whose large areas of a single color and strong contours and patterning he emulated. An even more formative influence on the young artist was the work of Edgar Degas, whose concern with movement and expression Toulouse-Lautrec began to interpret in a way that stressed angular protrusions of the body and outlandish behavior.

He was by this time haunting the dance halls and nightclubs of Montmartre, taking his subjects from his observations of what occurred on stage and among the patrons. To convey the frenetic and artificial atmosphere of these pleasure spots in such works as *At the Moulin Rouge* (1892; Art Institute of Chicago) and *La Goulue at the Moulin Rouge* (1892; Museum of Modern Art, New York City), he chose acid and garish colors and adopted a drawing style that is almost grotesque in its exaggerations. He applied the same techniques to the striking posters he designed (1890s) to advertise night spots and to immortalize the style and mannerisms of their most celebrated performers, including the dancers Jane Avril and Loie Fuller and the singers Aristide Bruant and Yvette Guilbert. In creating these famous works he greatly advanced the art of color lithography. His surviving drawings and sketches for the posters give the effect of speed and casualness, but in fact they represent a painstaking discipline and mastery in their extended use of line and reduction to essentials. The linear and uncluttered appearance of these works, as well as their flat, almost two-dimensional quality, owed much to Japanese art.

Alcoholism led to the failure of his health in 1899, and for the last few years of his life he confined his efforts to painting or drawing circus and jockey scenes from memory.

touraco [toor'-uh-koh] Touracos are arboreal, often exotically colored African birds, the 21 species of which constitute the family Musophagidae. Usually seen in pairs, touracos have loud, distinctive calls. Ranging from 38 to 70 cm (15 to 28 in) in length, they have long tails and a reversible fourth toe and are frequently colored in combinations of blue and green. Most species have a crimson color on their wings as a result of a unique pigment, turacin. Some also have a unique green pigment, turacoverdin. Touracos feed mainly on fruits, insects, and snails.

The great blue touraco is native to the dense forests of West Africa. The largest of all touracos, it reaches 70 cm (28 in) in length.

Touraine [too-ren'] Touraine is a historic region in the Loire valley of west central France, largely corresponding with the department of Indre-et-Loire. Tours, the medieval capital, is the region's industrial and commercial center. The Loire valley's fertile soil supports nursery gardens, meadows, orchards, and vineyards. The region's tourist industry is connected with its renowned Renaissance châteaux, such as Amboise, Chinon, Azay-le-Rideau, Chenonceaux, and Valençay, which were built during the 15th and 16th centuries. The name *Touraine* is derived from the Turones, a Gallic people conquered by the Romans. After centuries of rule by the counts of Blois and Anjou, Touraine came under English control in 1154 but was conquered (1203–05) by Philip II of France.

Touré, Sékou [too-ray', say-koo'] Ahmed Sékou Touré, b. Jan. 9, 1922, d. Mar. 27, 1984, a son of peasant farmers, was the first president (1958–84) of Guinea. The charismatic Touré, a pan-Africanist and a socialist, began his public career in labor-union activities. He helped to found (1946) an African nationalist party, served (1950s) as mayor of Conakry and deputy from Guinea to the French National Assembly, and became president when Guinea voted to become fully independent rather than join the French Community. Touré, who also served as prime minister (1958–72) and head of Guinea's only party, silenced all internal dissent.

Tourette's syndrome Gilles de la Tourette's disease, commonly known as Tourette's syndrome, is a rare neurological disorder characterized by involuntary utterances (sometimes including vulgarities) and body movements and by tics. The disease is usually manifested during early childhood and often worsens through adolescence. The syndrome's obvious and attention-getting symptoms add to the emotional stress of its victims, which can exacerbate their condition. Males are afflicted three to four times more often than females, although familial patterns are more prevalent in female patients. The cause is not known, and there is no known cure. Symptomatic treatment has been successful in a large percentage of cases, however, with carefully controlled dosages of butyprophenones (tranquilizers). The disease is named for the French physician Gilles de la Tourette, who first described the syndrome in 1885.

tourism The term *tourism* refers both to travel undertaken for pleasure and to the modern multimillion-dollar business that caters to the tourist's need for transportation, accommodation, food, entertainment, recreation, and social contact.

International tourism as a major industry did not get under way until the 1950s. Of the many factors contributing to this boom, the two most important were U.S. prosperity relative to the economy of war-ravaged Europe, which gave the U.S. dollar unusual purchasing power abroad, and the advent of jet travel in 1958, which made it possible to cross the Atlantic in seven to eight hours, half the time taken by propeller aircraft and about one-eighteenth that required by surface transport—all for approximately the same price. Jet speeds not only made accessible places that were previously considered remote, such as the South Pacific, the Far East, South America, and Africa, but also opened up the world of international travel to ordinary working people with only a short annual vacation.

Adding to the convenience and attractiveness of long-distance tourism were the availability of traveler's checks, which reduced the risks of travel; the incentive of reduced fares by way of Eurail passes, issued by Europe's state-owned railway systems; the growth in the United States of reduced-fare charter flights for groups; deferred payment plans; travel packages that combined several different kinds of transportation options in addition to meeting the tourist's preferences in hotel accommodations and guided tours; and a wide variety of specialized group tours.

Since the 1960s the nationals of most European countries, once again prosperous after a postwar economic struggle of 15 to 20 years, and of Japan have also shared in these travel trends. Tourism, in fact, plays a substantial role in the economies of many European countries—Austria, Greece, Italy, Spain, and Switzerland, for instance—where revenues from the tourist industry make an essential contribution toward reducing unfavorable balances of trade. It plays an even larger economic role in developing African and Caribbean nations.

Statistically, Europe as a geographic area remains the international favorite among tourists (many of European origin themselves). In 1989 about 7 million Americans visited Europe, spending almost $12 billion. Overall, in 1990, 44 million U.S. travelers abroad spent about $48 billion, while foreign visitors to the United States, numbering about 39 million, spent about $51 billion. Americans spend more money in Western Europe than in any other single area. Among European countries, the United Kingdom is still the uncontested front-runner with American tourists; France, Germany, and Italy are the next most frequently traveled European countries. The most popular destinations for U.S. tourists after Europe are Mexico and Canada.

Tourism in the United States and its possessions is also big business. It is the most important industry in Hawaii, for instance, and accounts for 75 percent of the economy of the American Virgin Islands. In fact, according to the American Society of Travel Agents, tourism constitutes the first, second, or third most important industry in 46 of the 50 states.

Tourism in the future may be affected by circumstances difficult to predict, as it has been in the past—the gasoline shortage of the 1970s and periodic weakness of the dollar relative to the harder currencies of some other countries. No doubt, like the stately passenger liners that were converted into hotels or year-round cruise ships once the days of their transatlantic runs had ended, Americans will adjust their travel plans to whatever circumstances exist. One thing seemed certain: by 1980, with more than half of all Americans taking at least one trip per year of 200 miles or more requiring a flight or hotel stay, tourism had become an essential feature of the American way of life, no longer a pastime reserved for the privileged few.

tourmaline [tur'-muh-leen] Tourmaline, a widespread and abundant complex boron and aluminum SILICATE MINERAL, $(Na,Ca)(Mg, Fe^{+2},Fe^{+3},Al,Li)_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$, is a birthstone for October. Prismatic crystals (hexagonal system) occur in parallel or radiating groups. Hardness is 7 to 7½, luster is vitreous to resinous, and specific gravity is 3.0 to 3.2. Tourmalines containing sodium, potassium, or lithium are pink (rubellite), blue (indicolite), or green (Brazilian emerald); magnesium tourmaline is brown (dravite), and iron tourmaline is black (schorl). Color gradation is common, with pink at one end of a crystal grading into green at the other. Tourmalines develop an electrical charge when heated or deformed, and slabs cut perpendicular to the long axis can polarize light.

The best developed tourmaline crystals are most commonly found in pegmatites. Most gem material comes from gem gravels in Sri Lanka and from pegmatites in Madagascar, the Ural Mountains, and Maine.

Tourmaline, a common, highly complex boron and aluminum silicate, is a popular gemstone because it is found in almost every conceivable color. Some crystals may change color from one end to the other or show concentric bands of pink and green.

Tournai [toor-nay'] Tournai (Flemish: Doornik) is a city in southwestern Belgium, located on the Scheldt River, 75 km (47 mi) southwest of Brussels. It has a population of 44,900 (1987 est.). During the Middle Ages, Tournai was a center for artisans and became famous for tapestry weaving and copperware. Other industries include quarrying and the manufacture of steel and leather goods. Landmarks include the Cathedral of Notre Dame (11th–12th century), the Belfry (1188), the Pont des Trous (13th century), and the Tower of Henry VIII (1513–16).

Originally a Roman city, Tournai became a Merovingian capital in the 6th century. Subsequently it belonged to Flanders, France, England, and the Netherlands; since 1830 it has been a part of Belgium.

Tourneur, Cyril [tur'-nur] The English dramatist Cyril Tourneur, b. *c.*1575, d. Feb. 28, 1626, is thought to have written *The Revenger's Tragedy* (1607), the outstanding example of a revenge tragedy and one of the supreme achievements of Jacobean drama. In the only play certainly by Tourneur, *The Atheist's Tragedy* (1611), also a revenge tragedy, religious prohibitions are set against the blood-revenger's duty, with God finally intervening directly to take vengeance.

Tours [toor] Tours, a city in west central France with a population of 132,209 (1982), lies about 210 km (130 mi) southwest of Paris on the Loire River. The principal manufactures are silk, processed foods, building materials, footwear, chemicals, and electrical equipment. Tours also serves as an agricultural trading center. Historic landmarks include the Gothic Cathedral of Saint-Gatien and the remains of the Basilica of Saint-Martin, both begun in the 12th century.

The Roman Tours was known as Caesarodunum from about AD 150 and as Civitas Turonum from the 5th century. Two of its bishops, Saint Martin (d. 397) and Gregory of Tours (d. 594), made the city famous. Following the introduction of the silk industry in the 15th century, Tours prospered, but its Huguenot population was dispersed after the revocation (1685) of the Edict of Nantes. From September to December 1870, Tours was the seat of the French government during the siege of Paris in the Franco-Prussian War.

Toussaint L'Ouverture, François Dominique [too-san' loo-vair-tuer'] More than any other individual, François Dominique Toussaint L'Ouverture, b. 1743, d. Apr. 7, 1803, was the liberator of Haiti, the first independent nation in Latin America. Although born in Haiti to African slave parents, Toussaint was said to be the grandson of an African king and was literate in French and Latin. Trained as a veterinarian, he worked in his plantation's stables and participated in the Haitian slave uprising of the 1790s. In 1793 he joined the Spanish army that had attacked the French in Haiti, but in 1794 he allied himself with the French, who had promised to abolish slavery, and was promoted to the rank of general.

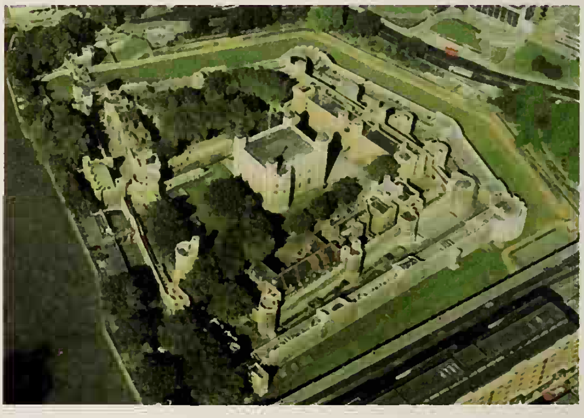
Toussaint's efforts in preventing a Spanish-English invasion earned him the titles of lieutenant governor and commander in chief of the Haitian forces. He proved to be an excellent administrator and strategist: the mulatto-held south was reincorporated into the black-dominated north; the British withdrew in 1798; and the Spanish were pushed out of the eastern part of the island.

By 1801, Toussaint ruled all of the island of Hispaniola with only nominal deference to France, and he assumed the title of governor-general for life. Napoleon I, however, anxious to reestablish French authority, dispatched Gen. Charles Leclerc with 20,000 troops to the colony in January 1802. Forced to surrender a few months later, Toussaint was imprisoned in France, where he died. The French invasion proved unsuccessful, and Haiti achieved its independence in 1804.

Tower of Babel see BABEL, TOWER OF

Tower of London The Tower of London is an ancient building complex at the edge of the City of London on the north bank of the Thames. Now a well-known monument, the first section—the White Tower—was begun by William I (r. 1066–87) in 1078, shortly after the Norman Conquest. The structure is actually made up of concentric fortifications—extended in the 12th and 13th centuries—that include 13 towers, including the Bloody Tower. The Beauchamp Tower, which probably dates from the 13th century, is named for Thomas de Beauchamp, earl of Warwick, who was imprisoned there by Richard II in 1397.

Many famous people were imprisoned in the Tower, and some of them, including Lady Jane Grey, Thomas More, Anne Boleyn, and Walter Raleigh, were executed there. Henry VI was murdered there, as—almost certainly—were the so-called Princes in the Tower, Edward V and his brother. A royal residence until the reign (1603–25) of James I, the Tower has also served as a storehouse for ordnance, records, and animals; at one time it was also the mint. The Crown Jewels are displayed at the Tower of London in an underground vault under the parade ground in front of Waterloo Barracks. The yeoman warders who guard the tower are called BEEFEATERS and still wear a picturesque Tudor uniform.



The concentric fortifications of the Tower of London surround the White Tower, built by William the Conqueror. The Traitors' Gate (left) *was once the main entrance. Immediately behind it are the square Bloody Tower, where, allegedly, the Princes in the Tower were murdered in 1485, and the round Wakefield Tower.*

towhee [toh'-ee] Named for their calls, towhees are the seven species of North American songbirds constituting the genus *Pipilo* in the finch family, Fringillidae. The migratory rufous-sided towhee, *P. erythrophthalmus*, is chestnut flanked and grows to about 23 cm (9 in). The other towhees, found predominantly in the western United States, have widely varying plumages. Ground feeders that scratch about for seeds and insects, towhees can be beneficial to agriculture by consuming the seeds of weeds.

town meeting A town meeting is an assembly of the qualified voters of a community for the purpose of attending to public business. The institution originated with the first settlers of the Massachusetts Bay Colony, who stipulated church membership as the major qualification. In colonial times the meetings were generally held weekly, but nowadays the voters are summoned, usually in the spring, by a warrant that sets forth the agenda to be discussed. Although the town meeting exists outside New England, it flourishes most vigorously there. It is often cited as the purest form of direct democracy because every citizen has the right to speak in debate and vote on legislation. The decisions of the people are executed by their elected officials, the selectmen, who, in effect, govern during the intervals between meetings.

Townes, Charles Hard [townz] The American physicist Charles Hard Townes, b. Greenville, S.C., July 28, 1915, shared the 1964 Nobel Prize for physics for his investigations into quantum electronics and his invention (1953) of the MASER, a device that generates a powerful pulse of microwaves. During the late 1950s, Townes developed solid-state masers that amplified ultra-weak signals with great efficiency, and in 1958 he developed the concept of the LASER.

Townsend, Francis Everett Francis Everett Townsend, b. Livingston County, Ill., Jan. 13, 1867, d. Sept. 1, 1960, an American physician, proposed and helped publicize a controversial old-age assistance plan during the Depression of the 1930s. Townsend suggested (1933) that all retirees over the age of 60 should receive $200 a month (in scrip) to be spent within the month, the funds to come from a national sales tax. In 1934 he established Old Age Revolving Pensions, Ltd., a loose organization of local clubs that within two years numbered 7,000—with a total membership of about 1.5 million. The popularity of Townsend's proposals was a factor leading to the passage of the Social Security Act in 1935.

Townshend, Charles Townshend, 2d Viscount Charles Townshend, 2d Viscount Townshend, b. Apr. 18, 1674, d. June 21, 1738, was a British Whig statesman and agricultural innovator whose political career was closely involved with that of Sir Robert WALPOLE, his brother-in-law. Townshend was secretary of state for the northern department from 1714 to 1716 and again held (1721–30) that post during the period of Walpole's ministry. He seemed to be the senior partner, until his adventurous foreign policy brought the two into conflict during the late 1720s. Walpole's growing strength at court enabled him to force Townshend's resignation in 1730. In retirement Townshend devised improvements in farming, particularly in crop rotation, that made him an important figure in the history of agricultural science.

Townshend Acts The Townshend Acts, British legislation intended to raise revenue, tighten customs enforcement, and assert imperial authority in America, were sponsored by Chancellor of the Exchequer Charles Townshend (1725–67) and enacted on June 29, 1767. The key statute levied import duties on glass, lead, paint, paper, and tea. Other bills authorized blank search warrants called WRITS OF ASSISTANCE, created three additional vice-admiralty courts, which operated without juries, established a board of customs commissioners headquartered in Boston, and suspended the New York assembly for not complying with the Quartering Act of 1765.

Americans protested the Townshend duties, as they had the earlier STAMP ACT, with constitutional petitions, boycotts, and violence. They now rejected all forms of parliamentary taxation, whether external duties on imports or internal taxes like the stamp levies. The protests ended with the repeal (1770) of the duties except for the ultimately explosive Tea Tax.

township A township, in the United States, is a geographical and political division of a county. In the Middle Atlantic states the township is often the basic unit of local government, assuming many of the functions carried out by county governments elsewhere. Townships can choose their own officers and committees. There is often a local police force, fire-protection company, tax assessor, clerk, treasurer, health official, sheriff, and mayor. In the United States the township is also a basic survey unit of measurement—set by the Ordinance of 1787 for western lands; a public-land township measures 6 mi^2 (9.7 km^2) and contains 36 sections.

toxic shock syndrome Toxic shock syndrome (TSS) is a relatively rare disease associated with infections by varieties of the common bacterium *Staphylococcus aureus*. It is apparently caused by absorption of a bacterial toxin into the bloodstream of persons lacking antibodies against the toxin. Symptoms include sudden onset of high fever, vomiting, diarrhea, low blood pressure, and a sunburnlike skin rash. About 75% of the cases affect menstruating women, but TSS also occurs in children, men, and nonmenstruating women; 30% of the patients experience more than one attack, and 10% of all cases are fatal.

In menstruating women, TSS has been associated with use of superabsorbing tampons containing fibers that strongly absorb magnesium, which seems to enhance toxin production. In other persons, TSS has been linked with various infections and the use of some contraceptive devices. Preventive measures for menstruating women include not using tampons or using them intermittently with external pads. Treatment includes antibiotic and supportive therapy and short-term use of corticosteroids.

toxic wastes see POLLUTANTS, CHEMICAL

toxicology Toxicology is the science of POISONS, including not only their physical and chemical effects but also their detection and antidotes. Toxicity is the ability of a substance to produce injury upon reaching a susceptible site in or on the body.

Substances are ranked according to a system of toxicity ratings used to indicate their relative hazard: *unknown toxicity*, for substances for which insufficient toxicity data are available; *no toxicity*, for materials that cause no harm under conditions of normal use or that produce toxic effects only because of overwhelming dosages or unusual conditions; *slight toxicity*, for materials that produce only slight effects on the skin or other organs of the body from either a single (acute) or repeated (chronic) exposure; *moderate toxicity*, for materials producing moderate effects on the skin or other organs of the body from either acute or chronic exposure; and *severe toxicity*, for materials that threaten life or cause permanent physical impairment or disfigurement from such exposure.

The dosage level and the period of time over which the dosage occurs determine the effect of a substance on an organism. Normally safe substances, such as salt and water, can cause illness or even death if consumed in sufficient amounts. Recognized poisons can differ from each other in toxicity by factors as great as 10 billion.

LD_{50} is a notation describing toxic level: a statistical estimate of the dosage required to kill 50% of an indefinite population of test animals. ED_{50}, a more general notation, describes the median effective dosage required to produce a specified effect in 50% of the population; such an effect, for example, may be tumor production or inhibition of enzyme production. Other factors in determining toxicity include exposure route, physical nature of the toxicant, temperature, humidity, and condition of the subject. The determination of the toxicity and dosage of a substance involves exposing isolated living tissues, cells, and various animals to the substance. Normally, no testing is performed on human volunteers until animal studies are completed.

A tremendous number of substances can act as poisons, and an organism can be exposed to these substances by various routes. As a result, toxicology has branched into several specialized areas, including economic toxicology, concerned with chemicals used in drugs, food additives, pesticides, and cosmetics; forensic toxicology, involving the medical and legal aspects of poisonous materials when death or severe injury is the result of their use; industrial toxicology, in which the effects of pollutants in the working environment are evaluated (see POLLUTANTS, CHEMICAL); and environmental toxicology, which is the evaluation of the synergistic effects of chemicals in the environment.

toxoplasmosis Toxoplasmosis is a disease caused by the protozoan *Toxoplasma gondii*, which lives in muscle and brain cells of a host animal and is acquired when uncooked, infected tissue is eaten. In cats, the parasite can live in intestinal cells, and people risk infection by contact with the cat's feces. Toxoplasmosis damages the brain, eyes, muscle, heart, liver, or lungs. If acquired during pregnancy, the parasite can severely damage the fetus. Certain phases of the disease respond to sulfonamides used with pyrimethamine. France and Austria require prenatal testing for toxoplasmosis and treat infected women with the antibiotic spiramycin to reduce the risk of transmission of the parasite to the fetus. The United States does not require such testing.

toy Toys are play objects used primarily by children. Natural objects, such as sticks, fir cones, seed pods, bones, and smooth round stones, may well have been the first toys. DOLLS, balls, spin-tops, and pull-toys made of a wide variety of materials are the fundamental toys of nearly every culture.

The animal was another early and fundamental toy shape. Although some of the animal figures found at ancient sites were used as ornaments or as miniature representations of objects intended to accompany the dead into the afterlife, a few animal shapes have been found that seem to have been intended for use only in play.

Little is known about the types of toys used by European children prior to the 13th century AD, when woodcuts and the decorations in illuminated manuscripts began to include illustrations of hobbyhorses, toy windmills, bubble pipes, puppets, balls, kites, and other toys.

Toys had been almost entirely handcrafted until late in the 18th century, when mass-produced toys began to appear for the first time. Metal rapidly replaced wood in many toys, and mechanical toys—windup animals, clockwork dolls, and inexpensive music boxes—became a standard toy type. (Music boxes had once been available only to adults as a costly curiosity.) Optical toys then made their mass appearance. A favorite was the cylindrical zoetrope, through which one could see a picture "move" as one turned the cylinder. In the 19th century dollhouses reflected the Victorian penchant for cluttered opulence, and some had working lifts and other ingenious mechanical devices.

In the 20th century, toys have proliferated along with other items of mass production. New materials have increased the range of possible toy shapes and functions. Replacing the tin soldier, a new population of detailed plastic fighting figures, from GI Joe to highly advanced and aggressive creatures from outer space, have made their way out of Saturday-morning television cartoons to the shelves of toy retailers—over the objections of many parent groups, who fear the hostile and sexist attitudes of this new generation of "war" toys. New "robots" range from small, unwired creatures whose shapes can be transformed into cars or planes, to electronic objects capable of obeying control-box commands. Toy supermarket chains have become big business and contribute to the enormous success of whole toy genres, such as the phenomenal Cabbage Patch Dolls. In reaction to the vast numbers of look-alike toys on toy-store shelves, many seek out simple wooden and cloth toys, often handcrafted, usually reproductions of the more innocent playthings of earlier childhoods. Nostalgia may also be responsible for the reborn enthusiasm for the teddy bear, a toy dear to many adults as well as to children.

See also: GAMES; PLAY (in behavior).

Toynbee, Arnold [toyn'-bee] Arnold Joseph Toynbee, b. Apr. 14, 1889, d. Oct. 22, 1975, a British historian and philosopher, searched for patterns in the growth and decay of civilizations. In his monumental *Study of History* (12 vols., 1934–61), the best known of his many works, Toynbee stated that the breakdown of a civilization occurs when creative minorities fail to respond successfully to challenges and give way to dominant minorities ruling merely by force over masses turned into proletariats. In the early volumes, published in the 1930s, Toynbee contended that the West would not escape this fate. Later, however, he predicted the development of a universal religion combining the best in Western and Eastern traditions and leading to the founding of a new order. Toynbee's work remains significant as a challenge to the Europocentric approach of historical scholarship.

Arnold Toynbee is considered one of the 20th century's most eminent philosophers of history. His comprehensive exploration of the cyclical patterns of civilization, manifested in his 12-volume Study of History, *has elicited both acclaim and controversy.*

Trabzon [trab-zohn'] Trabzon (Trebizond) is a Black Sea port in northeastern Turkey, with a population of 142,008 (1985). Exports include nuts, beans, tobacco, hides, and minerals. Founded as Trapezus by Greeks in 756 BC, it became an important Roman outpost in the 1st century AD. When the Fourth Crusade seized the Byzantine capital, Constantinople, in 1204, Byzantine refugees established the empire of Trebizond. It continued as a separate state after the Byzantines recovered (1261) control of Constantinople and became a commercial center. It held out against Ottoman Turkish conquest until 1461.

trachea [tray'-kee-uh] The trachea, or windpipe, is a cylindrical air tube extending from the lower part of the larynx, or voice box, downward approximately 11 cm (4.4 in) in adults to branch into two air tubes, called the bronchi. The walls of the trachea are composed of two layers. The innermost layer, the mucosa, is a moist membrane whose free surface is lined with epithelial tissue containing a few mucus-producing cells and numerous ciliated cells. The mucus serves to lubricate the passageway. The cilia, small hairlike processes extending from the free surface of the cells, beat back and forth, driving the mucus, and any particles that the mucus entraps, toward the throat.

The outermost layer of the tracheal wall is the cartilaginous layer. This layer is composed of 16 to 20 incomplete cartilaginous rings whose open ends are directed backward. These rings are embedded in connective tissue containing smooth muscle fibers and are formed into complete rings by a strip of ligament called the annular ligament. These rings keep the trachea open. The tracheal wall is covered with connective tissue that supports blood vessels, lymph vessels, and nerve fibers from the autonomic nervous system.

tracheophyte [tray'-kee-oh-fyt] Tracheophytes are plants of the phylum Tracheophyta that, with the BRYOPHYTES, comprise the terrestrial plants. The term *tracheophyte* literally means "windpipe plant," a reference to the water-conducting cells, or xylem, of these plants. Xylem cells are empty and have wall thickenings, thereby resembling the trachea of an animal. The tracheophytes are the dominant land plants and include all trees.

Both bryophytes and tracheophytes have an ALTERNATION OF GENERATIONS in their reproductive cycles. The gametophyte, or gamete (sperm and egg)-producing plant, is succeeded by the sporophyte, or spore-producing plant. Tracheophytes may be either homosporous or heterosporous. Almost all ferns, horsetails, and some club mosses are homosporous. Following meiosis, they produce spores that give rise to gametophytes bearing both male and female organs. A few ferns, some club mosses, and all seed plants are heterosporous. They produce two types of spores: the microspores, which give rise to male gametophytes, and the megaspores, which give rise to female gametophytes. The recognizable form of the bryophytes is the gametophyte, and the sporophyte is the familiar form of the tracheophytes. The more evolved the tracheophyte, the smaller the gametophyte stage. The most commonly known male gamete of tracheophytes is the pollen of GYMNOSPERMS and ANGIOSPERMS. The female gamete of these members is a microscopic ovule, the embryo sac. Ovules mature into SEEDS following fertilization. The organ systems evolve in the sporophyte generation, accompanied by the development of vascular systems: xylem (dead cells) and phloem (live cells).

The most primitive tracheophyte, genus *Psilotum*, lacks true roots and leaves. Club mosses have all organ systems, but their leaves are primitive, and the leaves of horsetails are degenerate. Ferns have advanced leaves. Seeds first appear in the gymnosperms. Angiosperms are the most advanced group.

trachoma [truh-koh'-muh] Trachoma, a contagious bacterial disease of the conjunctiva, lids, and cornea of the eye, results in a chronic inflammation that may eventually lead to corneal scarring and blindness. Caused by a strain of *Chlamydia trachomatis*, it is an extremely important problem because it affects more than 400 million people, particularly in the developing countries of Asia and Africa. Although rare in the United States, it is found in American Indians of the Southwest. Because antibiotics are effective treatment for this disease, the World Health Organization in association with local health agencies has mounted a worldwide offensive against trachoma.

track and field Track and field, or athletics as it is called in many countries, is the designation given to contests for men and women that involve running, jumping for height and distance, and throwing for distance using implements of standardized design. Competitions in track and field are called meets and are usually held outdoors, with the running events taking place on a portion of or around a 400-m (437.4-yd) oval made out of cinders, clay, or synthetic compounds.

The field events—which involve jumping and throwing—generally take place at the same time as the running events, on the area within the track's circumference, or nearby.

Meets are held indoors during the winter months on smaller ovals, which vary from 5 to 12 laps to the mile in size. Races of differing lengths from those held outdoors are often run, and several of the field events that require a large space are not held. Indoor tracks are generally made of wood and are often banked to offset the sharp turns.

Separate but related sports are often considered to be part of the track-and-field family. Cross-country is a fall and winter activity for distance runners, with races of 3.2–19.3 km (2–12 mi) being run over pastoral terrain. Road running, especially of the MARATHON distance (26 mi 385 yd/42.2 km) is an increasingly popular activity, with races taking place over a measured course on city streets or country roads. Road races may be of any length, up to and beyond 160 m (99.4 mi). Long-distance walking events are usually held on road courses as well.

The outdoor track season is usually March to June in the United States and through September in Europe and Asia. The cross-country season is generally from September until early December in the United States, although in Europe meets are often held throughout the winter until the start of the outdoor track season. Indoor meets are held in the winter months, December through March. Road races are held throughout the year, regardless of weather conditions.

History

Track and field is one of the oldest of sports. Athletic contests were often held in conjunction with religious festivals, as with the OLYMPIC GAMES of ancient Greece. For 11 centuries, starting in 776 BC, these affairs—for men only—were enormously popular and prestigious events. The Romans continued the Olympic tradition until the time of the Christian emperor Theodosius, who banned the Games in AD 394. During the Middle Ages, except for a short-lived revival in 12th-century England, organized track and field all but disappeared. The true development of track and field as a modern sport started in England during the 19th century. English public school and university students gave the sport impetus through their interclass meets, or meetings as they are still called in Britain, and in 1849 the Royal Military Academy held the first organized track and field meet of modern times.

Not until the 1860s, however, did the sport flourish. In 1866 the first English championships were held by the newly formed Amateur Athletic Club. The Amateur Athletic Club gave way to the Amateur Athletic Association in 1880, which has conducted the annual national championships since that date. Although meets were held on the North American continent as early as 1839, track and field first gained popularity in the late 1860s, after the formation of the New York Athletic Club in 1868. The AMATEUR ATHLETIC UNION OF THE UNITED STATES (AAU), an association of track and field clubs, was formed in 1887 and has governed the sport in the United States since then.

In 1896 the first modern Olympic Games were staged. Although initially of limited appeal, the Olympics captured the imagination of athletes and grew steadily, making track and field an international sport for the first time. In 1913 the International Amateur Athletic Federation (IAAF) was formed by representatives from 16 countries. The IAAF was charged with establishing standard rules for the sport and approving world records; it continues to carry out these duties today.

The participation of women in track and field is a relatively recent development. In 1921, representatives from six countries formed an athletic federation for women, which merged with the IAAF in 1936. Participation by women has grown rapidly in many countries in recent years, particularly in the United States, where many schools have added women's track and field to their athletic programs.

Rules and Scoring

All races are started by the firing of a gun by an official at the starting line. For races up to and including one lap of an outdoor track, the runners must stay for the entire distance within lanes marked on the track. There may be six to eight lanes, with each lane usually measuring 1.2 m (4 ft) in width. The winner in each race is the runner whose torso first breaks the vertical plane of the finish line. Races are timed either by mechanical watches or by more sophisticated, electronic photo-timers that can measure finishes to the hundredth of a second. Sometimes, owing to the number of contestants in a competition, qualifying rounds, or heats, are held to narrow the contestants down to the fastest runners.

Athletes in the field events also have qualifying rounds. In the horizontal jumps and throws, athletes are allowed three preliminary attempts if the field numbers more than eight participants. Then the best performers are allowed three more attempts. In the vertical jumps—the high jump and pole vault—the participants are allowed to continue until they have three successive failures. If two or more contestants tie, the competitor with the fewest failures at the last height cleared is the winner; if still tied, the total number of failures is the deciding factor; if a tie remains, the total number of jumps is considered. Scoring systems differ according to the meet. Many national competitions are scored on the basis of 10 points for first place, 8 for second, on down to 1 point for sixth. In international meets, the scoring is 5 for first place, 3 for second, 2 for third, and 1 for fourth. The team with the highest total wins.

For road races, cross-country meets, and walking competitions, the winner is given 1 point, the second-place finisher 2 points, and so on; the finish positions are totaled, and the team with the lowest score is the winner.

Track Events

The sprints are all-out efforts over the entire distance run. Outdoors the sprints are 100, 200, and 400 m (109.3, 218.6, and 437.2 yd). Indoor sprints are often as short as 50 yd (45.7 m), or as long as 500 m (546.8 yd).

Sprinters use a crouch start in which, after being commanded to get "on your marks" by the starter, the contestant kneels with one knee on the ground and both hands resting behind the starting line. On the "get set" command, the sprinter raises the knee from the ground in anticipation of the gun. When it fires, the runner will accelerate as quickly as possible from the starting line. To facilitate a quick start by giving the runner something to push off against, devices known as starting blocks are used.

In the longer sprints—200 m and 400 m—the races are run in assigned lanes for the entire circumference of the track. To ensure fairness for all participants, the start is staggered so that runners farther out from the inside lane start farther ahead of the contestants to their left, who have a smaller circumference to run around; as a result, all runners travel the same distance.

American sprinter Florence Griffith Joyner rounds the curve in the 200-meter final at the 1988 Olympic Games in Seoul, South Korea. During 1988, Griffith Joyner emerged as the world's fastest woman, running a world record 10.49-sec 100 m in July and a world record 21.34-sec 200 m in Seoul.

The middle distance races range from 800 to 2,000 m (874.4 to 2,187.2 yd), although by far the most popular of these events has been the mile (1.6 km); top runners often complete the mile in less than four minutes. Such is the popularity of the mile that it is the only event of English measure still recognized by the IAAF for record purposes. While the 880-yd (804.7-m), 2-mi (3.2-km), and other English distances are still run, only metric marks are now ratifiable as world records. In the middle distances, fatigue becomes an increasingly important factor, requiring the competitors to pace themselves so that they can finish the race in the shortest possible time; or, if the race is a tactical one, to be able to summon a sprint at the end in order to defeat the other contestants.

The long distances range from 3,000 to 30,000 m (1.9 to 18.6 mi) and the marathon. Also recognized by the IAAF is the one-hour run, in which the participants run as far as they can within one hour's time. As with the middle distances, the longer the race, the less decisive is the inherent speed of the various competitors. Rather, the endurance fitness of the athletes and their use of various strategies play a more important role. A distance runner with less natural speed than his or her rivals may speed up the pace in the middle of a race in order to break away from and thus disconcert the other runners.

Besides the distance races on the track, which usually are no farther than 10,000 m (6.2 mi), many of the longer races are run on the roads. Because of the varying venues and conditions, no world records are kept by the IAAF for these road races. Similarly, no records are kept for cross-country races, which, at the international level, are often 12,000 m (7.4 mi). Perhaps the most unusual of the distance track events is the 3,000-m (1.9-mi) STEEPLECHASE, in which the contestants must negotiate 28 sturdy wooden barriers and 7 water jumps. Race walking, on the other hand, is fast walking with the stipulation that the walker must maintain unbroken contact with the ground and lock the knee for an instant while the foot is on the ground.

The hurdle races require an athlete to possess the speed of a sprinter and the ability to clear 10 barriers 106.7 cm (42 in) high in the men's 110-m (120.3-yd) hurdles, and 10 barriers of 91.4 cm (36 in) in the 400-m hurdles. Women race over 100 m and 10 barriers 84 cm (33 in) high. In both men's and women's races, no penalty is assessed for knocking down hurdles, unless done deliberately with the hand. The rear leg or foot may not trail alongside the hurdle, but must be drawn over the top.

In the relay races teams of four athletes run separate distances, or legs. They exchange a hollow tube called a baton within designated exchange zones. The most common relay events are the 4 × 100-m relay and the 4 × 400-m relay. Relay meets are particularly popular in the United States, owing in part to the American school sys-

MEN'S WORLD TRACK AND FIELD RECORDS

Event	*Record*	*Record Holder*	*Date*
100 m	9.86 sec	Carl Lewis (USA)	Aug. 25, 1991
200 m	19.72 sec	Pietro Mennea (Italy)	Sept. 12, 1979
400 m	43.29 sec	Butch Reynolds (USA)	Aug. 17, 1988
800 m	1 min 41.73 sec	Sebastian Coe (UK)	June 10, 1981
1,000 m	2 min 12.18 sec	Sebastian Coe (UK)	July 11, 1981
1,500 m	3 min 28.86 sec	Noureddine Morceli (Alg.)	Sept. 6, 1992
Mile	3 min 46.32 sec	Steve Cram (UK)	July 27, 1985
2,000 m	4 min 50.81 sec	Said Aouita (Mor.)	July 16, 1987
3,000 m	7 min 28.96 sec	Moses Kiptanui (Kenya)	Aug. 16, 1992
Steeplechase	8 min 02.08 sec	Moses Kiptanui (Kenya)	Aug. 19, 1992
5,000 m	12 min 58.39 sec	Said Aouita (Mor.)	July 22, 1987
10,000 m	27 min 08.23 sec	Arturo Barrios (Mex.)	Aug. 18, 1989
20,000 m	56 min 55.6 sec	Arturo Barrios (Mex.)	Mar. 30, 1991
25,000 m	1 hr 13 min 55.8 sec	Toshihiko Seko (Japan)	Mar. 22, 1981
30,000 m	1 hr 29 min 18.8 sec	Toshihiko Seko (Japan)	Mar. 22, 1981
Marathon	2 hr 6 min 50 sec	Belaine Densimo (Eth.)	Apr. 17, 1988
110-m hurdles	12.92 sec	Roger Kingdom (USA)	Aug. 16, 1989
400-m hurdles	46.78 sec	Kevin Young (USA)	Aug. 6, 1992
High jump	2.44 m (8 ft)	Javier Sotomayor (Cuba)	July 29, 1989
Pole vault	6.13 m (20 ft 1¼ in.)	Sergei Bubka (Ukr.)	Sept. 19, 1992
Long jump	8.95 m (29 ft 4.5 in)	Mike Powell (USA)	Aug. 30, 1991
Triple jump	17.97 m (58 ft 11½ in)	Willie Banks (USA)	June 16, 1985
Shot put	23.12 m (75 ft 10¼ in)	Randy Barnes (USA)	May 20, 1990
Discus throw	74.08 m (243 ft)	Jurgen Schult (E.Ger.)	June 6, 1986
Hammer throw	86.74 m (284 ft 7 in)	Yuri Sedykh (USSR)	Aug. 30, 1986
Javelin throw	91.46 m (300 ft 1 in)	Steve Backley (UK)	Jan. 25, 1992
Decathlon	8,891 points	Dan O'Brien (USA)	Sep. 4–5, 1992
20-km walk	1 hr 18 min 35.2 sec	Stefan Johanssen (Swed.)	May 15, 1992
30-km walk	2 hr 3 min 56.5 sec	Thierry Toutain (France)	Mar. 24, 1991
50-km walk	3 hr 41 min 39 sec	Raul Gonzales (Mex.)	May 25, 1979
4 × 100-m relay	37.40 sec	USA (M. Marsh, L. Burrell, D. Mitchell, C. Lewis)	Aug. 8, 1992
4 × 200-m relay	1 min 19.11 sec	Santa Monica Track Club (M. Marsh, L. Burrell, F. Heard, C. Lewis)	Apr. 25, 1992
4 × 400-m relay	2 min 55.74 sec	USA (A. Valmon, Q. Watts, M. Johnson, C. Lewis)	Aug. 8, 1992
4 × 800-m relay	7 min 3.89 sec	UK (P. Elliott, G. Cook, S. Cram, S. Coe)	Aug. 30, 1982
4 × 1,500-m relay	14 min 38.8 sec	W.Ger. (T. Wessinghage, H. Hudak, M. Lederer, K. Fleschen)	Aug. 17, 1977

tem, which has traditionally placed emphasis on interscholastic team competition.

Field Events

Competitors in the high jump attempt to clear a crossbar. The contestant may make the takeoff for the high jump using only one foot, not two. Over the past half-century, jumping styles have changed dramatically. Most competitors today use the "flop" style, which was popularized by Dick Fosbury, an American who developed the style and used it to win the 1968 Olympic gold medal. The athlete approaches the bar almost straight on, then twists his or her body so that the back is facing the bar before landing in the pit. These landing areas, which at one time were recesses filled with sawdust, are now well-padded foam-rubber mats.

In the pole vault, as in the high jump, the object is for the athlete to pass over a bar without knocking it off, in this case with the aid of a pole. In the vault, too, a foam-rubber pit is employed to break the athlete's fall. Because the IAAF rules place no restrictions on the composition of the pole, it has undergone dramatic changes as new materials have become available. Bamboo and heavy metal models have given way to the fiberglass pole, which has a high degree of flexibility and allows the athlete to catapult over the bar.

In the long jump, or broad jump as it was once called, the contestants run at full speed down a cinder or synthetic runway to a takeoff board. This board marks the point where the athlete must leave the ground. After a legal jump, the contestant's mark is measured from the front edge of the takeoff board to the nearest point of contact in the sand-filled pit.

The triple jump requires its contestants to hop, step, and jump into the pit. When the athlete reaches the board, he or she takes off and lands on the same foot; then, while attempting to maintain momentum, the ath-

Soviet pole vaulter Sergei Bubka, seen here clearing the bar by an extraordinary margin, was nearly unbeatable in his event from the mid-1980s, raising the world standard many times. He won the 1988, but not the 1992, Olympic gold medal.

WOMEN'S WORLD TRACK AND FIELD RECORDS

Event	*Record*	*Record Holder*	*Date*
100 m	10.49 sec	Florence Griffith Joyner (USA)	July 16, 1988
200 m	21.34 sec	Florence Griffith Joyner (USA)	Sept. 29, 1988
400 m	47.60 sec	Marita Koch (E.Ger.)	Oct. 6, 1985
800 m	1 min 53.28 sec	Jarmila Kratochvilova (Czech.)	July 26, 1983
1,500 m	3 min 52.47 sec	Tatyana Kazankina (USSR)	Aug. 13, 1980
Mile	4 min 15.61 sec	Paula Ivan (Rom.)	July 10, 1989
3,000 m	8 min 22.62 sec	Tatyana Kazankina (USSR)	Aug. 26, 1984
5,000 m	14 min 37.33 sec	Ingrid Kristiansen (Nor.)	Aug. 5, 1986
10,000 m	30 min 13.74 sec	Ingrid Kristiansen (Nor.)	July 5, 1986
Marathon	2 hr 21 min 6 sec	Ingrid Kristiansen (Nor.)	Apr. 21, 1985
100-m hurdles	12.21 sec	Yordanka Donkova (Bulg.)	Aug. 21, 1988
400-m hurdles	52.94 sec	Marina Stepanova (USSR)	Sept. 17, 1986
High jump	2.09 m (6 ft 10¼ in)	Stefka Kostadinova (Bulg.)	Aug. 30, 1987
Long jump	7.52 m (24 ft 8¼ in)	Galina Chistyakova (USSR)	June 11, 1988
Shot put	22.63 m (74 ft 3 in)	Natalya Lisovskaya (USSR)	June 7, 1987
Discus throw	76.80 m (252 ft)	Gabriele Reinsch (E.Ger.)	July 9, 1988
Javelin throw	80.00 m (262 ft 5 in)	Petra Felke (E.Ger.)	Sept. 9, 1988
Heptathlon	7,291 points	Jackie Joyner-Kersee (USA)	Sept. 23-24, 1988
4 × 100-m relay	41.37 sec	E.Ger. (S. Gladisch, S. Rieger, I. Auerswald, M. Gohr)	Oct. 6, 1985
4 × 200-m relay	1 min 28.15 sec	E.Ger. (R. Müller, B. Wockel, M. Koch, M. Gohr)	Aug. 9, 1980
4 × 400-m relay	3 min 15.18 sec	USSR (T. Ledovskaya, O. Nazarova, M. Pinigina, O. Bryzgina)	Oct. 10, 1988
4 × 800-m relay	7 min 50.17 sec	USSR (N. Olizarenko, L. Gurina, L. Borisova, I. Podyalova)	Aug. 5, 1984

lete takes an exaggerated step, landing on the opposite foot and then continues into the pit with a third jump, landing with both feet.

In the shot put, as in the other throwing events in track and field, the competitors perform from a circular base constructed of concrete or synthetic material. The shot is a 16-lb (7.26-kg) metal ball—8 lb 13 oz (4 kg) for women—that the athletes try to "put," or throw, as far as possible from within a circle 7 ft (2.1 m) in diameter.

The discus throw employs a platelike implement weighing 2 kg (4 lb 6.55 oz) for men and 1 kg (2 lb 3.27 oz) for women. It is one of the oldest of events; it was popular in the ancient Greek Olympics. Standing in a circle 2.5 m (8 ft 2.5 in) in diameter, the athlete rests the discus in the throwing hand. He or she then makes one and one-half quick turns and releases the discus at shoulder level.

The implement used in the hammer throw is actually a metal ball similar to the shot. It is attached to a handle by a 3 ft 11.75-in-long (1.21-m) steel wire, and the entire implement weighs 16 lb. The athlete turns several times in the circle, gripping the handle of the hammer with both hands, and attempts to release at the moment of maximum centrifugal force. Indoors, a short-handled version of the hammer, weighing 35 lb (15.9 kg), is used.

The javelin is a spearlike shaft of wood or metal at least 260 cm (8 ft 6.62 in) long for men and 220 cm (7 ft 2.61 in) for women, with a metal tip at one end and a grip bound around the shaft at the approximate center of gravity. After a short but rapid approach run, the 800-g (1 lb 12.2-oz) javelin—600 g (1 lb 5.16 oz) for women—is thrown overhand.

Often held at major track meets are the DECATHLON for men and the heptathlon for women (see PENTATHLON), events that test all-around capabilities.

tracking station Tracking stations are optical, radar, and radio facilities used to collect data from spacecraft and rockets. Tracking stations are usually ground based but have been placed aboard ships, aircraft, and satellites. Optical tracking is used mainly for orbit determination of inactive spacecraft or of satellites equipped with optical ranging devices. Radio tracking is used extensively to acquire data from spacecraft and to transmit commands. Communications ranges can be as short as hundreds of meters at launch or as long as billions of kilometers.

Manned space missions place the greatest demand on tracking networks, which must monitor spacecraft systems, crew health, and science equipment and transmit voice and video as well. Project Apollo, which placed men on the Moon, monitored the missions with tracking stations extending down the Atlantic Ocean from Cape Canaveral. They were joined by other stations for Earth-orbit tracking and supplemented by tracking ships and modified Boeing 707 jets. Deep-space communications were maintained by 26-m and 64-m-wide (85-ft and 210-ft) paraboloid antennas at Madrid, Spain; Honeysuckle Creek, Australia; and Goldstone, Calif. For use by the SPACE SHUTTLE program and other projects, NASA has augmented its facilities with three Tracking and Data Relay Satellites (TDRS) that collect data and transmit them to ground facilities through a station at White Sands, N.Mex.

A number of systems have been developed for tracking unmanned satellites and detecting missiles. These include the radar stations of the Ballistic Missile Early Warning System (see BMEWS) and the air force's Pave Paws system for detecting submarine-launched missiles.

tractor The term *tractor* generally refers to a self-propelled pulling, pushing, and powering machine used in construction, mining, and agriculture. The word is also used for the tractor cab, the hauling end of a trucking rig.

The work tractor is a multipurpose machine that is mounted on crawler tracks or rubber tires; it provides low-speed tractive power on its own, and it may also be used as a mount and power source for machines such as pipe-laying equipment, front-end loaders, and bulldozers. The truck tractor is a powerful vehicle that is used to haul an unpowered trailer, forming a tractor-trailer rig. Many such tractors are diesel-powered, but gas turbines may be used on especially large vehicles. Designed solely for road-speed operation, truck tractors may have two or more axles. Loads can be changed quickly by switching trailers, which can then be loaded and unloaded without restricting the use of the tractor (see TRUCKING INDUSTRY).

Tracy, Spencer The actor Spencer Tracy, b. Milwaukee, Wis., Apr. 5, 1900, d. June 10, 1967, was a top screen star for 40 years and is especially remembered for his film partnership with Katharine HEPBURN. Among the nine movies they made together are *Woman of the Year* (1942), *Adam's Rib* (1949), and *Guess Who's Coming to Dinner?* (1967), Tracy's last. He won Academy Awards for his performances as a fisherman in *Captains Courageous* (1937) and Father Flanagan in *Boys Town* (1938).

Spencer Tracy, an American actor of great range and virtuosity, remained one of Hollywood's most important personalities for more than 40 years. A compelling dramatic performer known for his sensitive character portrayals, Tracy is also remembered for the light comedic roles he played opposite Katharine Hepburn.

trade associations A trade association is a nonprofit organization of business enterprises that are engaged in a particular industry or trade. Business firms voluntarily join a trade association to gain benefits for their industry or trade group that will also benefit them individually. By acting collectively, firms can often bring about results that they could not achieve on their own. Some trade associations represent huge industries and have many members: for example, the National Automobile Dealers Association numbers about 20,000. Small or specialty industries may have only a few members; the Gold-filled Manufacturers Association has 6. Trade associations usually represent a trade group or industry within a single country.

Trade associations have a variety of functions. They help promote trade for the industry as a whole through such means as advertising. They also facilitate the exchange of relevant information within a particular industry. Other trade-association functions include the provision of a forum for the discussion and resolution of common problems; the promulgation of codes of ethics and procedures regulating business practices within the industry; the standardization of products; and the sponsoring of industry-related research.

The beginnings of trade associations can be traced back to the guild system of the Middle Ages. Modern U.S. trade associations had their origins in the formation of the National Association of Cotton Manufacturers (1854) and other manufacturing associations prior to the Civil War.

trade fairs Trade fairs are exhibitions designed to display new products for the purpose of promoting their sale and utilization. They have developed from a long tradition of bazaars, caravans, and fairs dating back to ancient times. Throughout history fairs have been held to facilitate buying, selling, and bartering. The European fair—the ones held in various towns of the French region of Champagne were particularly notable—reached its peak in the 13th and 14th centuries but began to decline as an institution when goods became more easily available through the introduction of modern merchandising methods, particularly permanent shops. In the United States the fair developed as an exhibition, mainly of agricultural and horticultural products. The first permanent fair was initiated by Elkanah Watson in Pittsfield, Mass., in 1810, and the enthusiastic response to it led to the development of annual state and county fairs, eventually across the entire country. The first of the WORLD'S FAIRS, the CRYSTAL PALACE exposition in London in 1851, was essentially an elaborate trade show.

See also: CARNIVALS AND FAIRS.

trade union see LABOR UNION

trade winds The trade winds, or trades, which are a major component of the general circulation of the atmosphere, are the winds that occupy the lowest kilometer (0.6 mi) of the atmosphere over most of the tropical oceans. The pressure difference between the subtropical highs (semipermanent high-pressure centers located near 30° north and 30° south latitudes in the Atlantic and Pacific oceans) and the equatorial trough (a band of low pressure extending around the Earth near the equator) produces an equatorially directed force that opposes the Coriolis force (arising from the rotation of the Earth) and frictional drag at the air-sea interface. The trade winds, which result from the balance among these three forces, blow from the northeast over areas north of the equatorial trough and from the southeast over areas south of the equatorial trough. The transition between the northeast and southeast trades occurs generally in a narrow band several degrees north of the equator; this region is called the intertropical convergence zone, or ITCZ (see TROPICAL CLIMATE).

trademark A trademark is a word or words, name, symbol, label, device, or picture applied or attached to a manufacturer's or merchant's product to identify it and distinguish it from similar products sold by others. Its most common form is the brand name. A trademark is different from both a COPYRIGHT and a PATENT. In a trademark the protection is in the symbol that distinguishes the product, not in the product itself.

A trademark in the United States comes into being as soon as and for as long as it is used. Trademarks that are not properly protected, however, may become generic terms and available to all manufacturers. Registering trademarks helps protect them. In the United States, trademark-registration provisions were first enacted by Congress in 1870 and modified in 1881 and 1905. Federal registration under the Lanham Trademark Act of 1946 is made by filing an application, labels confirming trademark use, and a fee with the U.S. Patent and Trademark Office. Most Western countries, the USSR, and Japan have similar trademark requirements, although many countries do not require use prior to registration.

Trades Union Congress The Trades Union Congress (TUC) in Great Britain is the organization that represents the collective interests of labor unions on a wide range of issues. Founded at Manchester in 1868, the TUC acquired a socialist orientation at the turn of the century, influenced by the syndicalist (see SYNDICALISM) concept of one union for all workers. The TUC operates as a lobbying group, not as a governing body, and each of the 91 member unions retains the right of independent action to advance the economic interests of its members, who total about 9.8 million.

Trafalgar, Battle of [truh-fal'-gur] The Battle of Trafalgar (Oct. 21, 1805), a decisive sea clash of the NAPOLEONIC WARS, destroyed NAPOLEON I's plans for an invasion of England. Adm. Horatio NELSON, commanding a British fleet of 27 ships, defeated a combined French-Spanish fleet of 33 ships under Admiral Villeneuve off Spain's southwest coast by breaking through the French battle line and capturing 17 ships. Nelson's words before the battle, "England expects that every man will do his duty," have become immortal. He died in the battle.

traffic control The term *traffic control* refers not only to road, rail, sea, and air transportation but also the traffic of shoppers in a supermarket, the flow of papers in large offices, and the movement of components on an assembly line. This article discusses only TRANSPORTATION traffic. For the other types, see SYSTEMS ENGINEERING.

The primary aims of all traffic-control systems are to speed the traveler and to save fuel, but almost everywhere the crisis of congested systems has supervened. Thus the most urgent objective of present-day control systems is to increase capacity, unblock problem points, and maintain safety. Contemporary transportation systems are so large that funds are not available to pay for new facilities needed.

Railroads. The first fully controlled transportation mode in the West was the early RAILROAD, which for the first time introduced a complete control system under central management. A system of visual SIGNALING was introduced to warn of obstructions ahead, and telegraphic communication (later telephone and radio) was used throughout the system. In recent years fully automatic train control has been introduced, including, for example, conductive cable systems laid between the rails to sense train speed, transmit instructions, and, if necessary, cause trains to change speed or stop.

Roads. On ROADS AND HIGHWAYS progress has been slower and except for general road improvement has been confined to the cities. Some forms of traffic control are simple and relatively inexpensive; these include speed limits, one-way streets, prohibition of turning across oncoming traffic, tidal-flow schemes where lanes are reversed at peak hours, and—above all—clear signs indicating that these controls are in effect. Some improvements, however, require more money. Electric traffic signals were introduced in 1928. Basic QUEUEING THEORY, formulated in 1908 by A. K. Erlang in a study of Copenhagen's telephone system, has assisted in speeding traffic flow of all kinds.

Aviation. The mode of transportation subject to the most advanced and costly control is AVIATION. Much of the world's airspace over land areas is controlled and is divided into air corridors linking large terminal airspaces. All areas are divided into Flight Information Regions, each with a traffic control center and radio communications. Most advanced aircraft have precision navigation systems (see GUIDANCE AND CONTROL SYSTEMS). Thus aircraft can maintain their position on fixed routes accurately, usually flying at known and reported flight levels (height above ground), and in the neighborhood of airports can be controlled with the utmost precision by traffic controllers (see AIRPORT). Rules in force depend on the weather and type of aircraft. Special rules govern separation of traffic on different routes, military airplanes, and such low fliers as agricultural crop dusters.

Shipping. Sea traffic has been greatly assisted by RADAR and the development of precision navigation aids and collision-warning systems. Despite this assistance, accidents and collisions at sea continue to occur, and sea traffic is more in need of proper control than any other mode of transportation. Even in dense traffic areas the only rule is to avoid other ships, and for many years the introduction of a proper sea-traffic control system has been urged. The dangers have magnified with increasing size of the vessels, and the threat (and actual occurrence) of collisions between large tankers is especially serious.

tragedy As a literary term, *tragedy* refers to a drama in which a heroic protagonist meets an unhappy or calamitous end, brought about by some fatal flaw of character, by circumstances outside his or her control, or simply by destiny. Invented and developed in ancient Greece (see GREEK LITERATURE, ANCIENT), tragic drama has had a long history in Western literature.

Greek Tragedy. It is believed that Greek tragedy emerged from the cult of DIONYSUS, god of fertility, wine, and poetry. At first, chants and dances were performed in honor of the god and his attendants by a chorus whose leader, the coryphaeus, engaged in chanted dialogue with the group. In the middle of the 6th century BC, the Athenian poet THESPIS replaced the coryphaeus by a distinct actor, the protagonist, who, being masked, could actually play several roles if he withdrew to the wings whenever the chorus performed alone. The great innovation of AESCHYLUS was to introduce a second actor, so that a dialogue could take place between two individuals in addition to the dialogue between actor and chorus. SOPHOCLES and EURIPIDES used a third actor, and with this the formal evolution of Greek tragedy came to an end.

Roman, Renaissance, and Early Modern Tragedy. Of Roman tragedy—closely modeled on that of Greece—only the works of Lucius Annaeus SENECA influenced later epochs. The short duration of the brilliant phase of creation in Greece is matched by the brevity of other great periods of tragic drama in Western civilization: Elizabethan England—a few decades on either side of 1600; the Spanish Golden Age—roughly the same period; France—from the 1630s to the 1690s; Germany—approximately three decades on either side of 1800. It may be argued, however, that during the 19th century such novelists as Dostoyevsky, Melville, and Hardy successfully transferred the tragic vision from the drama to the novel.

The Tragic Vision. The first and still the most influential definition of tragic drama was sketched out in the *Poetics* of ARISTOTLE. For Aristotle tragedy is a unified action; it is serious, complete, plausible; it has action of substantial magnitude; most important, it concerns the fall of a hero whose misfortune is brought about not by vice or depravity but by some error or frailty—the tragic flaw; its incidents arouse "the pleasure of pity and fear" and by so doing accomplish the purgation or catharsis of these emotions in the audience.

In the Renaissance such rules as the unities of time, place, and action were derived from Aristotle. Thus the great tragedies of the French playwrights Pierre CORNEILLE and Jean RACINE restricted their actions to a single place, such as a room in a palace, and to a single day, while subordinate actions—especially comic ones—and low or vulgar words were rigorously excluded. By contrast, William SHAKESPEARE in England and Lope de VEGA in Spain disregarded many of these rules and wrote tragedies that ignore many of the classical prescriptions. Both the classical and the romantic approach bore fruit in the tragedies of GOETHE and SCHILLER.

Contemporary Tragedy. A recurring issue during the 20th century has been whether truly tragic literature is still possible. Traditionally, tragedy had attached a terrifying importance to the destiny of humanity. Now it is asked whether in a debunking and unheroic age such a vision of human stature can be sustained. A play such as T. S. ELIOT's *Murder in the Cathedral* or Jean Anouilh's *Antigone* (1944; Eng. trans., 1946) is cast in the old heroic mold, but are works such as Eugene O'NEILL's LONG DAY'S JOURNEY INTO NIGHT or Arthur MILLER's DEATH OF A SALESMAN tragic, or—because their protagonists are "nobodies"—merely pathetic? If such works are indeed modern tragedies, then the concept of tragedy has changed significantly, although essential points, such as sympathy for the protagonist and the inevitability of his or her downfall, firmly bind 20th-century tragedy to the tradition.

tragicomedy Tragicomedy is a sophisticated and deliberately ambiguous genre of drama that combines and somehow fuses the mutually opposed patterns and responses of TRAGEDY and COMEDY. Unlike comedy, tragicomedy stirs deep emotions and directly confronts human suffering, mortality, and death. Unlike tragedy, tragicomedy rejects absolutes, the inevitability of catastrophe, and the need for heroism and sacrifice.

The Roman dramatist PLAUTUS first used the term *tragicomedy* in the prologue to *Amphitryon,* a play that violated decorum by dealing with both gods and slaves and by mixing the heroic and the farcical. The genre flourished during the Renaissance, producing in Italy two pastoral tragicomedies, Tasso's *Aminta* (1573) and Guarini's *Il pastor fido* (The Faithful Shepherd, 1590). Shakespeare's late tragicomic romances, The TEMPEST and *Cymbeline*, followed a precedent established by the tragicomedies of Francis Beaumont and John Fletcher (see BEAUMONT, FRANCIS AND FLETCHER, JOHN).

In the modern era, starting with IBSEN's *The Wild Duck* and continuing to the plays of Beckett, Ionesco, and Pinter, tragicomedy has again become an important dramatic form for presenting the unresolved dualities of existence. Characterized by jarring discontinuity of tone and action, contemporary tragicomedy leaves the spectator bewildered and uncertain whether to laugh or cry. As in Beckett's WAITING FOR GODOT, the tragicomic mode often self-consciously calls attention to itself as theater.

See also: THEATER OF THE ABSURD.

trailing arbutus Trailing arbutus is the common name for *Epigaea repens*, a creeping evergreen shrub of the family Ericaceae. Native to North America, it grows particularly well in the shade of pine trees in the eastern United States. The tubular white or pink flower cluster is the state flower of Massachusetts.

Trajan, Roman Emperor [tray'-juhn] Trajan (Marcus Ulpius Traianus), b. Sept. 18, AD 53, d. August 117, Roman emperor (AD 98–117), pursued an aggressive, expansionist policy and gained a reputation for his benevolence. Born in Roman Spain, he distinguished himself early in military and political posts and in AD 97 received from the emperor Nerva (r. 96–98) the rank of caesar and a share of imperial power. Supported by the military, Tra-

The Roman emperor Trajan (r. 98–117) extended the boundaries of the empire to include Dacia and part of the eastern kingdom of Parthia. In addition to his military achievements, Trajan implemented highly successful civil, economic, and social programs.

jan became sole emperor on Nerva's death. An effective administrator, Trajan reduced taxes and sponsored subsidies for the poor, a massive building program, and the admission of provincials to prominent positions. He became best known, however, for his campaigns against the Dacians (101–02, 105–06), which led to the creation of a Roman province north of the Danube, and for his war with PARTHIAN (113–17), Rome's principal adversary in the East. Trajan captured the Parthian capital, CTESIPHON, and marched to the Persian Gulf but could not eliminate resistance. By Trajan's death the Parthians were again in control of most of the overrun territory.

trampoline see GYMNASTICS

tranquilizer Tranquilizers are a group of drugs prescribed to relieve ANXIETY, tension, and agitation while having comparatively few adverse effects. Because they act as mild depressants on the central nervous system, however, they can lead to drowsiness and some degree of mental confusion. Also known as ataractics or anxiolytics, they are sometimes grouped as the "mild" tranquilizers, in contrast with stronger SEDATIVES such as barbiturates, the psychotropic drugs used in the treatment of mental disorders, and ALCOHOL.

As a group, tranquilizers are the most commonly used prescription drugs in the United States. They include the benzodiazepines (such as VALIUM and Librium), the diphenylmethanes (Vistaril and Atarax), and the propanidids (tybamate and meprobamate, also called Equanil and Miltown).

Anxiety, a normal response to STRESS, requires treatment only when the degree of physiological disturbance interferes with a patient's overall functioning. Such disturbances may include accelerated heart rate, palpitations, involuntary movements, sleep disorders, diarrhea, headaches, increased rate of urination, and gastric discomfort. Tranquilizers provide temporary relief in such instances, although the masking of symptoms in this way is potentially hazardous. With continuous use, tranquilizers decrease in effectiveness, and dependency can occur (see DRUG ABUSE). Buspirone hydrochloride (BuSpar) appears to avoid problems of drowsiness and possible dependency associated with other tranquilizers.

Trans-Alaska Pipeline The Trans-Alaska Pipeline is an oil pipeline that runs from Prudhoe Bay, an arm of the Arctic Ocean, 1,285 km (800 mi) south to Valdez, an ice-free port on the Gulf of Alaska (see PIPE AND PIPELINE). The 1.2-m-diameter (48-in) pipeline is designed to carry more than two million barrels of crude oil per day from the Alaskan North Slopes, located some 400 km (250 mi) north of the Arctic Circle.

The project, which received congressional approval in 1973, was opposed by environmentalists, who feared the harmful effects of the construction; some studies have shown that oil drilling in northern Alaska has indeed caused significant environmental damage. The pipeline was built by the Alyeska Pipeline Service Company, a consortium of 8 oil corporations, and was completed in 1977 at a cost of almost $8 billion. In addition to the pipeline, the project included a TANKER terminal at Valdez, 12 pumping stations, and the Yukon River Bridge, a joint venture of Alyeska and the state of Alaska.

U.S. West Coast–oil-refinery capacity has proved to be insufficient to handle the Alaskan crude, and much of the oil is carried by tanker to distant refineries.

Trans-Canada Highway The Trans-Canada Highway—begun in 1949, opened in 1962, and completed in 1965—is a 7,825-km-long (4,860-mi) road across southern Canada, from St. John's, Newfoundland, to Victoria on Vancouver Island, British Columbia. It is the longest national highway in the world. The paved, occasionally divided road, passing through all Canadian provinces, was jointly financed by the federal and provincial governments.

Trans-Siberian Railroad The Trans-Siberian Railroad is a Russian railroad connecting Moscow with Vladivostok. Completed in 1916, it is the longest continuous rail line in the world. During the 1880s, a line had been built as far east as Chelyabinsk, 1,700 km (1,054 mi) from Moscow. The major portion of the Siberian sectors were finished between 1891 and 1900. The completion of the Chinese Eastern Railway in Manchuria, and a short water connection across Lake Baikal, gave Russia a new transportation route across Asia by 1903. In 1904 a rail loop around the foot of Lake Baikal was opened, and in 1916 the Amur sector (located north of the Amur River) was finished.

Since 1916 several branch lines have been added, and recently much of the route has been electrified. The 1984 completion of a 3,200-km (2,000-mi) parallel rail line, the Baikal-Amur Mainline (BAM), 160 to 320 km

(100 to 200 mi) north of the Trans-Siberian Railroad in eastern Siberia, opened mineral-rich areas of Siberia to exploitation.

transactional analysis Transactional analysis, originated by Eric Berne and popularized by Thomas A. Harris, is a psychological theory that analyzes the structure of social interactions. In such interactions individuals assume three alternate personality states—"adult," "parent," and "child"—analogous to Freud's ego, superego, and id. Relationships are balanced if complementary states are presented; for instance, a husband's "child" balances a wife's "parent." Relationships are unbalanced and disruptive if nonreciprocal states are presented.

There are also four basic life positions that individuals take in interactions with others. These are stated as "I'm OK, you're OK"; "I'm OK, you're not OK"; "I'm not OK, you're OK"; "I'm not OK, you're not OK." People's lives are structured as "scripts" or life plans for obtaining certain "payoffs" or goals. People have a need for a minimum level of social gratification, or "strokes." In relationships, individuals repeatedly play out certain "games," eliciting psychological payoffs.

Psychotherapy from a transactional-analysis approach consists of identifying and analyzing the patient's styles and positions of interaction.

transcendence, divine The concept of divine transcendence states that God is elevated above and extrinsic to the universe that he created. In the Judeo-Christian tradition, God is viewed as combining the apparent opposites of transcendence and immanence in that he both transcends the universe and is active in it. Traditional Christian philosophy, exemplified particularly in the works of Thomas Aquinas, treats God as transcendent in the sense that he created the world; that he has perfect knowledge of all earthly things, which indeed derive from him; that he is infinite and eternal; and that, unlike humans, he is identical with his own essence.

transcendental function A transcendental function is a function that is not a root of a polynomial equation. Such functions arise frequently in mathematics and science. A function that is a root of a polynomial equation is an algebraic function; all other functions are called transcendental. The importance of transcendental functions stems from the fact that most of the functions that describe natural phenomena turn out to be transcendental functions. The six trigonometric functions (see TRIGONOMETRY)—sine, cosine, tangent, cotangent, secant, and cosecant—are all transcendental, for example, as are the logarithmic, exponential, and hyperbolic functions.

transcendental number A transcendental number is an IRRATIONAL NUMBER—meaning a number that cannot be represented as the quotient of two integers—that is also not a root of any polynomial equation with integer coefficients (see NUMBER). It was not established until 1851 (by Joseph Liouville) that transcendental numbers exist. In 1882, Ferdinand Lindemann proved that the number π (pi) is transcendental. One consequence of this result is that it demonstrated the impossibility of constructing by ruler and compass a circle and square of the same area. Today the theory of transcendental numbers is an active area of research and it has major applications in NUMBER THEORY.

transcendentalism Transcendentalism was an American movement that flourished from the mid-1830s until the mid-1840s. The transcendentalists generally believed in an intuitive idealism, the idea of an organic universe suffused by an immanent God, the divinity of humankind, and the importance of the individual's own moral insight as opposed to the rule of the many. Although the movement was short-lived, it helped change the direction of American literature, religion, and social thought.

Nearly all the major participants in the transcendental movement were men educated at Harvard College who went on to become Unitarian ministers living in the vicinity of Boston. In September 1836, Ralph Waldo EMERSON and three friends met in Boston for, in Emerson's words, "the free discussion of theological & moral subjects." From this group was formed the Transcendental Club, which met nearly 30 times over the next four years.

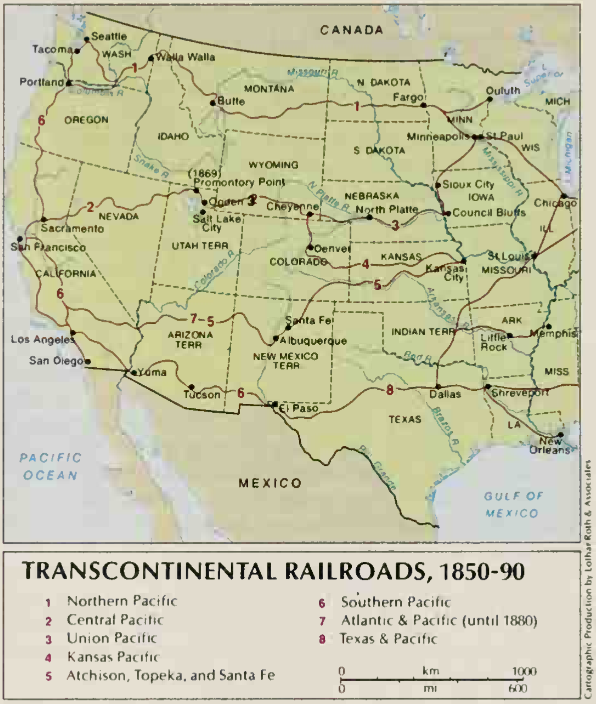
The most important member of the club—and of the movement—was Emerson. During the transcendental period he published five works that established his reputation: *Nature* (1836), the first book to state the basic principles of transcendentalism; the "American Scholar Address" (1837), which called for an original literature based on American themes; the "Divinity School Address" (1838), which called for a religion of inspiration to replace the formalism of the day; and *Essays* (1841) and *Essays: Second Series* (1844), which included such pieces as "Self-Reliance" and "The Poet." Through these works and well-attended public lectures, Emerson conveyed the group's concerns to a wide, interested audience.

Other transcendentalists tended to deal with specific areas within the large framework that Emerson had laid out. Bronson ALCOTT's inductive and Socratic philosophies of education were expressed in *Record of a School* (1835) and *Conversations with Children on the Gospels* (1836–37); Margaret FULLER's *Woman in the Nineteenth Century* (1845) decried the traditional stereotyped roles for men and women; and Theodore PARKER, in *A Discourse on the Transient and Permanent in Christianity* (1841) and *A Discourse of Matters Pertaining to Religion* (1842), argued for the permanent traits of intuitive religion as opposed to the passing doctrines, rites, and creeds of existing institutions. Finally, all the transcendentalists were involved in the antislavery movement.

Two periodicals were associated with the movement. The *Western Messenger* (1835–41)—edited for three years by Unitarian minister James Freeman CLARKE—was published in the Ohio Valley and supported the transcendentalists when most conservative journals opposed them. *The Dial* (1840–44), edited by Fuller and Emerson, featured numerous contributions by Parker, Henry David Thoreau, and the editors, and was the most visible gathering point for the group.

The transcendentalists also participated in two utopian communal efforts. Fruitlands (June 1843–January 1844), at Harvard, Mass., involved Alcott's family and a ragtag band of about a dozen. It failed through a combination of lack of funds, incompetent management, and internal bickering about its aims and methods. The Brook Farm community (April 1841–September 1847), at West Roxbury, Mass., was one of America's most famous communal experiments and the best example of the social aspect of transcendentalism. It was founded by George Ripley and his wife, Sophia, as a community in which everyone shared in the work and the profits yet had time for contemplation and artistic endeavors. In March 1845, influenced by the French utopian thinker Charles Fourier, the members reorganized as Brook Farm Phalanx, but Fourier's strictly regimented plans clashed with the transcendental concept of personal freedom, their finances—never solid to begin with—worsened, and a disastrous fire in 1846 assured Brook Farm's collapse.

Transcendentalism had an enduring impact. The challenges to the Unitarian establishment by Parker and others resulted in significant changes in that religion's organization. Alcott's educational reforms helped to accelerate acceptance of a belief that children should learn by thinking and not just by rote memorization. Emerson's eloquent expressions of organicism in art (everything proceeds from a natural order, followed by but not imposed upon man) did much to counteract the poetic conservatism of his day and helped lead to the experimental verse of Walt Whitman. Thoreau's belief in the importance of simple living in accordance with nature (*Walden*, 1854) has become part of the American canon. And Emerson's concept of self-reliance and Thoreau's idea of civil disobedience both lie behind the American belief that an individual must oppose laws thought to be unjust.



TRANSCONTINENTAL RAILROADS, 1850-90

Cartographic Production by Lothar Roth & Associates

transcontinental railroad The transcontinental railroad in North America became a reality on May 10, 1869, when the tracks of the Union Pacific joined those of the Central Pacific at Promontory Point, Utah. In 1853, Congress appropriated $150,000 to defray expenses of surveying feasible routes, but the question of the best one quickly became a matter of sectional controversy.

Once the South left the Union, Congress pushed through the Pacific Railroad Act (July 1, 1862), which authorized the Central Pacific to build eastward from San Francisco and the Union Pacific to build westward from Omaha, Nebr., via South Pass; the two were to join at the California-Nevada line. Each company was to receive 400 ft (122 m) of right-of-way through public (or 100 ft/31 m—through private) lands and 10 alternate square-mile sections of public land for each mile of tract laid. Loans of $16,000 to $48,000 per mile—depending on the grade of the terrain—were also available as a first mortgage on the railroad. In 1864, Congress doubled the land grant and made the financial subsidy a second lien on the property. It again amended the original legislation in 1866 to allow the Central Pacific to advance eastward until it met the Union Pacific, thereby turning the project into a construction race.

Chinese workers were employed by the Central Pacific, and the Union Pacific hired Irish immigrants and Civil War veterans. During the winter of 1868–69 the two railroads employed about 25,000 laborers.

Both lines experienced many problems. The Central Pacific had to ship in steel rails from the East Coast by sea, whereas the Union Pacific had to transport ballast and lumber for crossties from Wisconsin. The latter company experienced difficulty with the Plains Indians, primarily because railroad crews were slaughtering the Indians' buffalo herds for meat. The Central Pacific had to tunnel through the High Sierras, bridge deep gorges, and construct 40 mi (64 km) of snowsheds to protect against snow and avalanches. Ultimately, the Union Pacific laid 1,086 mi (1,747 km) of track, and the Central Pacific, 689 mi (1,109 km).

While the first transcontinental line was opening the Great Plains, three other railroads were pushing toward the West Coast. By 1883 the Southern Pacific connected New Orleans and Los Angeles, the Santa Fe ran between Chicago and Southern California via Albuquerque, and the Northern Pacific extended from Duluth to Portland.

transducer [tranz-doo'-sur] A transducer is a device that transforms input energy into output energy; the forms of the input and output energy may be identical or different. The electric conversion transducer, for example, changes electricity from one frequency to another, and some of the most common transducers change energy from one form into another. Among these are the electroacoustic transducer (sound into electricity), the piezoelectric (electricity into motion, or vice versa), and the ultrasonic (electricity into ultrasound). The MICROPHONE is a familiar electroacoustic transducer in which a sound wave causes a diaphragm to move, producing a change in some property of an electric current.

Piezoelectric transducers are crystals that can generate an electric charge when they are deformed by pressure or torque (see PIEZOELECTRICITY). A common example is the PHONOGRAPH needle, in which the motion of the stylus twists a piezoelectric crystal in order to produce an electric current. Other piezoelectric transducers, which vibrate at precise frequencies, are used widely in radio and television broadcasting.

Ultrasonic transducers produce ultrasonic energy (sound waves above the range of human hearing) by converting input electrical, mechanical, or hydraulic energy. Ultrasound is used in materials testing and as an alternative to X rays in medicine (see ULTRASONICS).

transept see CATHEDRALS AND CHURCHES

transference see PSYCHOANALYSIS

Transfiguration The Gospels according to Matthew (17:1–13), Mark (9:2–13), and Luke (9:28–36) describe an occasion on which Jesus took his disciples Peter, James, and John to a mountaintop (traditionally Mount Tabor, although Mount Hermon is preferred by many scholars) and there appeared "transfigured" (manifesting glory) with Moses and Elijah. The Transfiguration is understood by Christians as a testimony that Jesus fulfilled the Old Testament prophecies of the Messiah. The Feast of the Transfiguration is observed on Aug. 6.

transform fault Transform faults are the shear boundaries of the Earth's segmented crustal plates (see PLATE TECTONICS). The faults form at right angles to mid-oceanic ridges and are occasionally marked by scarps. In contrast to the mid-oceanic ridges, where new ocean crust is generated, and trenches (subduction zones), where crust is consumed, crust along transform faults is conserved as the adjacent crustal plates simply slide past one another. Most transform faults, like the other two types of plate boundaries, lie beneath the ocean, but the SAN ANDREAS FAULT in California is a prime example located on land. Strike-slip movement along a transform fault is associated with EARTHQUAKES that are less intense than those within subduction zones.

The name *transform fault* is derived from the displacement, or transformation, of a fault into a different type of plate boundary at the ends of the fault shear zone. This boundary is either a mid-oceanic ridge, a trench, or a triple junction (intersection of three crustal plates at one point). Both ends of the San Andreas Fault, northwest of San Francisco and south of the Gulf of California, are triple junctions.

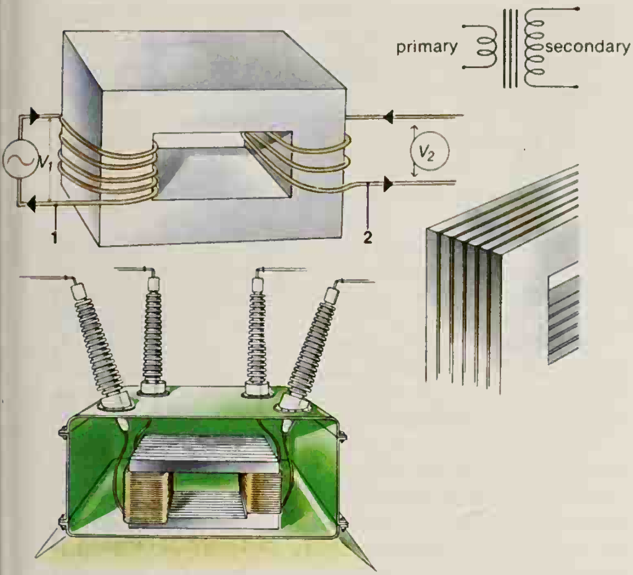
transformation In mathematics a transformation is a rule by which a given mathematical object may be changed into another one of the same kind. The idea of a transformation has its roots in the fact that the same object or event can be observed from different points of view, with its appearance depending on the viewpoint. For instance, a circle looks like a circle when viewed straight on but like an ellipse when viewed obliquely. There is a transformation law that indicates how to predict the apparent shape from the new viewpoint, given the shape from the old point of view. (Special mention should be made of the identity transformation, which leaves everything unchanged.) This idea has been most fruitful in mathematics and physics, where it has led to a number of theories, including Einstein's theory of relativity.

Most mathematical transformations may be classified as geometric or algebraic. A geometric transformation is a mapping of a geometrical object into itself. Algebraic transformations are rules for obtaining new algebraic expressions from old ones by making a substitution in the variables.

transformer A transformer is an electrical device that transfers electric energy from one coil, or winding, to another by electromagnetic induction. The transferred energy may be at a higher or lower voltage. Transformers can operate only on alternating current (AC) or on direct current with a superimposed AC component (pulsating DC).

Transformers are generally classed as step-up or step-down transformers. A step-up transformer increases the voltage, and a step-down transformer reduces it. At electric generating plants, step-up transformers (called generator transformers) increase the generator voltage to a higher voltage, which is then transmitted through power lines over long distances with little loss. In the locality where the electricity will be used, step-down transformers then lower the voltage. A distribution transformer makes the final step-down in voltage for homes and businesses. Consumers may use additional step-down transformers to operate such devices as doorbells and toy electric trains.

The operation of the transformer is based on the principle discovered in 1830 by Joseph Henry that electrical energy can be transferred efficiently by mutual ELECTROMAGNETIC INDUCTION from one winding to another. When the primary winding is energized by an AC source, an alternating magnetic flux is established in the transformer core. This flux links the turns of both primary and secondary, thereby inducing voltages in them. Because the same flux cuts both windings, the same voltage is induced in each turn of both windings. The total induced voltage in



A transformer raises or lowers the voltage of an electric current. To construct a transformer (upper left), *wire is coiled around each leg of a laminated metal core* (detail, lower right). *When alternating current enters the first coil* (1) *a magnetic field travels through the core and induces current in the second coil* (2). *The ratio between the number of windings in each coil determines whether the voltage* (V1, V2) *will be stepped up or stepped down. The standard diagram for a step-up transformer is seen at upper right. Large transformers require cooling and are usually submerged in a tank of oil* (lower left).

each winding is therefore proportional to the number of turns in that winding. This proportion is known as the turns ratio, which, when multiplied by the applied voltage, determines the secondary voltage. The primary is always connected to the source of power, and the secondary winding receives the electrical energy by mutual induction from the primary winding and delivers it to the connected electric load. In some transformer windings, taps are provided so that less than the full number of turns may be used.

Transformers are built in single-phase and polyphase units. Most power and distribution systems use three-phase lines. A three-phase transformer consists of separate insulated windings for the different phases. The windings are wound on a three-legged core capable of establishing three magnetic fluxes displaced by 120° in time phase. Transformers also may be classed according to the frequency range for which they are designed, such as audio frequency, power frequency, and radio frequency.

transistor The transistor is a solid-state electronic component that is able to control a relatively large electrical current flowing between two regions of a SEMICONDUCTOR crystal by a very small current or voltage applied to an intermediate region. This capability permits the transistor to act as a proportional amplifier or electronic switch, applications that formerly could be accomplished only with the ELECTRON TUBE.

Because the transistor is mechanically robust, produces relatively little heat, and is exceptionally small, its invention in 1948 by Walter H. Brattain, John Bardeen, and William Shockley at Bell Laboratories ushered in a new era of miniaturized electronics. The INTEGRATED CIRCUIT and other MICROELECTRONIC devices are among the most significant by-products of the transistor.

The first transistors were called point-contact devices because two of the three electrodes that made electrical contact to the component were tiny wires pressed against the surface of a small semiconductor crystal to form a closely spaced pair of rectifying regions—regions in which current can flow in one direction only. Point-contact transistors were inherently fragile. In 1952, Shockley invented a vastly improved form of transistor in which the rectifying contacts were replaced by a pair of internal pn junctions similar to the pn junction of a semiconductor junction diode. (A pn junction is the dividing surface between two semiconductor regions, n and p, of different conductivity.) All transistors can be classified as either bipolar or field-effect devices.

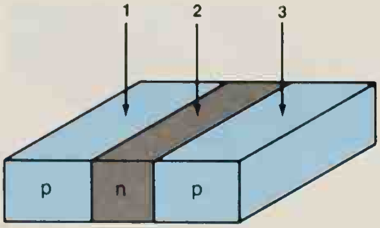
The Bipolar Transistor

The bipolar transistor is a small chip of semiconductor, ordinarily silicon or germanium, with an internal structure resembling two back-to-back junction diodes. This structure is achieved by transforming both ends of a bar of n-type semiconductor into p-type material. The result is a pair of pn junctions within a single semiconductor chip, and the transistor is called a pnp device. A second way to achieve the desired pair of junctions is to transform both ends of a p-type bar into n-type material to give an npn device.

Whether pnp or npn, the central region of the transistor, which is called the base, controls the current flowing between the two outer regions, which are called the emitter and collector.

Operation. In the operation of, for example, the npn transistor, electrons from an external source are injected into the emitter, where they readily cross over into the p-type base. The holes ("missing" electrons) in the base are quickly filled by the incoming electrons, and the resulting negative charge acts to repel further electrons that would otherwise arrive from the emitter.

A comparatively small positive current applied to the base can produce additional holes that will, in turn, permit more electrons to be injected into the base from the emitter. The base region contains significantly fewer holes than the emitter and collector contain free elec-



A pnp junction transistor consists of an n-type, or negative (n), *material between two p-type, or positive* (p), *bars. This transistor has three electrodes: an emitter* (1), *base* (2), *and collector* (3).

trons, so a substantial percentage of the injected electrons pass through the base and enter the collector before the holes in the base are filled. The application of additional holes into the base encourages more or less emitter-collector current flow, much as a throttle controls the speed of an engine.

Emitter current passes from the base to the collector even though the base is more positive than the collector (reverse bias). If the base-collector junction were fabricated like the pn junction in a conventional diode, only a tiny reverse current would flow.

In a transistor, however, the base is lightly doped and exceedingly thin, so that as many as 99% of the free electrons injected into the base are swept into the collector.

Applications. Because the emitter-collector current is up to several hundred times greater than the emitter-base current, the transistor qualifies as an efficient current amplifier.

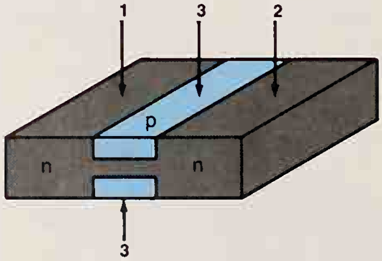
A junction transistor may also be used as an electronic switch. Below a point known as saturation, or cutoff, the ratio of the base current to the emitter-collector current is constant. At saturation the transistor reaches its highest possible conductivity, and further increases in base current fail to increase the emitter-collector current. A comparatively small base current easily saturates a transistor into full conduction and causes it to act as a solid-state on-off switch.

The Field Effect Transistor

The field effect transistor, or FET, was first conceived by J. E. Lilienfeld in 1925, but it was not until 1952 that Shockley, one of the coinventors of the bipolar transistor, proposed the detailed theory of FET operation. FETs may be classified according to their structure as junction or metal-oxide-semiconductor (MOS) devices. Both have certain characteristics that make them superior to bipolar (pnp and npn) transistors in several applications.

JFET. The junction FET, or JFET, consists of a silicon bar containing a narrow region of n- or p-type material, called the channel, that passes between two facing regions having an opposite polarity and called the gate regions. The FET is designated according to the polarity of its channel as either n-channel or p-channel. Electrical terminals called the source and drain are attached to either end of the channel. A terminal is also attached to the gate regions.

In the case of the n-channel FET, an electrical current can flow into the channel through the source, pass with relative ease through the channel, and exit via the drain. The current flow can be decreased by applying a negative voltage to the gate. This action depletes the number of free electrons in the channel, which would otherwise act as current carriers. More gate voltage expands the depletion regions on either side of the channel until they eventually merge and block the flow of current. The channel resistance is then very high, and pinch-off is said to have occurred.



In a junction field effect transistor with an n-type channel, two p-type layers are joined to a grooved n-type bar, or channel. External connections include: a source (1), *a drain* (2), *and a gate, or control electrode* (3).

A very small change in gate voltage is enough to alter a comparatively large current flow. Therefore the FET is a voltage amplifier and resembles a TRIODE electron tube more than a current amplifier such as the bipolar transistor.

MOSFETs. In the metal-oxide-semiconductor field effect transistor, or MOSFET, its gate is a film of metal separated from the upper surface of the silicon channel by an insulating layer of silicon dioxide.

Two principal kinds of MOSFETs exist. In the depletion type a current is able to flow between the source and drain terminals connected to either an n-type or p-type channel. A voltage applied to the gate increases the channel resistance by attracting current carriers to the region adjacent to the metal gate. As with the JFET, sufficient gate voltage will cause pinch-off to occur. In the enhancement MOSFET the channel resistance is normally high. Applying a voltage to the gate causes current carriers to be drawn into the channel, thus lowering its resistance.

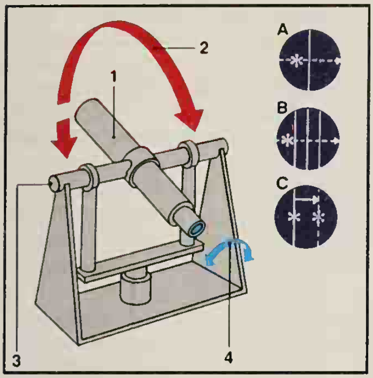
Both kinds of MOSFETs provide proportional control over the channel current by means of a voltage applied to the gate and therefore qualify as voltage amplifiers.

This enhanced impedance is accompanied by a potential disadvantage, however, because the MOSFET is highly susceptible to permanent damage from static electricity.

New Developments

Complementary metal-oxide-semiconductor circuitry, or CMOS, comprises pairs of n- and p-channel transistors that are controlled at the same time by a single circuit. This makes more efficient use of the chip and cuts down on both power need and heat production. For these reasons, CMOS technology is gaining wide acceptance despite its slower operating speeds. Emitted coupling logic, ECL, is a bipolar technology that is extremely fast but also expensive and not compatible with other technologies. Other areas of research include the development of gallium-arsenide chips, superconducting materials, and electron tunneling through junctions.

Transit Transit was a series of U.S. experimental satellites launched between 1959 and 1964 to prove that satellites could be used for navigational purposes. The primary instrumentation of a Transit satellite consisted of two ultrastable oscillators for use with a Doppler-shift navigation experiment, and a transmitter for sending data from a sensor that measured Earth's albedo in the infrared region and engineering information on the internal operation of the satellite. The system proved the usefulness of satellites as extremely accurate navigation aids for



The transit circle is a refracting telescope (1) used in a north-south direction along the plane of a celestial meridian (2). A grid of vertical wires enables the observer to track the passage of stars (A, B, C) across the meridian. The shaft (3) can be reversed to compensate for instrument errors. The mounting adjusts (4) to correct for east-west deviations.

ships, locating their positions to within less than 100 m (330 ft). The Transit system became fully operational in 1964 and was followed by similar satellites under such names as Navy Navigation Satellite and NAVSTAR.

transit, surveying see SURVEYING

transit circle A transit circle is an instrument designed to determine accurately the exact time at which a celestial object transits, or passes, an observer's celestial meridian, which is a fundamental reference circle from which star positions are measured. The instrument was invented by the Danish astronomer Ole Roemer in 1689. It consists of a telescope, generally 15 to 25 cm (6 to 10 in) in diameter, mounted so that it can rotate only in a north and south direction along the meridian. The telescope eyepiece contains a fine, movable vertical wire and a stationary grid of vertical wires, the central one of which coincides exactly with the meridian. The movable wire is kept centered on the observed star, planet, Sun, Moon, or other object by means of a micrometer screw, and the exact moment of meridian transit is recorded; in modern times such recordings are made electronically. The data obtained with transit circles are used to determine the right ascension of a celestial object, to make corrections to clocks used in observatories, and to determine the longitude of an observer's location. The declination, or angular distance of the object above the celestial equator, can also be read from a calibrated circle attached to the horizontal axis.

transition elements The chemical elements are arranged in the PERIODIC TABLE in such a way that each element progressively adds an electron to the ELECTRON CONFIGURATION of the previous element, filling subshells and shells of lowest energy (see ATOM). The transition elements are those that add electrons to an inner subshell after some electrons have taken positions in an outer shell. This is possible because the energy levels of the shells overlap. Thus the transition elements fill *d* or *f* subshells, while the representative elements fill *s* or *p* subshells. This article describes properties of the *d* transition elements of the three series, scandium to zinc, yttrium to cadmium, and lanthanum to mercury. The *f* transition elements are discussed in LANTHANIDE SERIES and ACTINIDE SERIES (actually transition series within a transition series).

General Properties. The transition elements are all METALS, a feature related to the presence of one or two electrons in the outermost shell of their atoms. They are generally hard, strong metals with high melting and boiling points; they are also usually electropositive—that is, they react by tending to lose, rather than gain, electrons. Certain unique properties of the transition elements are related to their *d* subshell electrons. These properties include variable oxidation states, formation of brightly colored compounds, tendency to form many complexes, and ferromagnetism and paramagnetism.

Oxidation States. The oxidation states of transition elements are usually written as Roman numerals; for example, Fe(III) represents the Fe^{3+} ion. The early elements of each transition series have their highest oxidation states equal to their group number in the periodic table; examples are Ti(IV), V(V), Cr(VI), and Mn(VII). The transition elements show a wide variety of oxidation states by easily sharing their *d* electrons with other elements in covalent bonds or by allowing electrons from other elements to enter their unfilled *d* orbitals. Manganese (VII) is usually covalently bonded as permanganate, MnO_4^-, sharing its 4*s* and 3*d* electrons with oxygen atoms. Manganese is an extreme example of a transition element displaying many oxidation states; every state from Mn(–III) to Mn(VII) is known.

Complexes. The formation and structures of complexes of many transition elements were first elucidated by Alfred Werner between 1892 and 1911. He explained why the two compounds $CoCl_3 \bullet S6NH_3$ and $CoCl_3 \bullet S5NH_3$ have strikingly different physical and chemical properties; they are COORDINATION COMPOUNDS in which six ligands surround each metal ion—six ammonia molecules in the former compound, correctly written as $[Co(NH_3)_6]Cl_3$, and five ammonia molecules and one chloride in the second, $[Co(NH_3)_5Cl]Cl_2$. Each transition-metal ion is found to display characteristic coordination numbers; cobalt (III) always has the coordination number 6.

Biological Occurrence. Transition metals form complexes with a wide variety of organic molecules, including many that have vital biological functions. For example, hemoglobin (oxygen transport) contains iron, and vitamin B_{12} (oxygen transfer) contains cobalt.

Transjordan see JORDAN

Transkei [tran-sky'] The Republic of Transkei, located on the east coast of South Africa, comprises three separate blocks of land bounded by the Indian Ocean on the east, the Drakensberg on the west, the Great Kei River on the south, Lesotho on the northwest, and Natal on the north. It was declared independent on Oct. 26, 1976. Under South Africa's APARTHEID policy, the 1959 Promotion of Self-Government Act called for the gradual creation of ten independent African homelands, of which

Transkei was the first. Transkei's independence, however, is not recognized by the United Nations or by any country other than South Africa. The territory covers 41,002 km^2 (15,831 mi^2).

Transkei's population of 4,367,648 (1990 est.) belongs primarily to the XHOSA ethnic group but includes several thousand whites and persons of mixed racial origin. Additional Xhosa reside in South Africa and in the Ciskei homeland. Transkei's population is primarily rural. The capital and largest city, Umtata, is linked by rail to East London.

The Xhosa are primarily subsistence cultivators and pastoralists. Because population pressure is high, the soil is severely eroded, and industrial opportunities are limited. Labor is Transkei's main export. Some light industry is centered in Umtata and Butterworth, but most manufactured goods and much food must be imported from South Africa, on which it is heavily dependent for financial aid.

In 1848, Transkei was annexed by Britain, and in 1865 it was joined to Cape Province. In 1959 it became the first South African bantustan, and subsequently it was the first bantustan to achieve self-government (1963) and then full "independence" (1976), with a single-chamber parliament that elected a president. At independence, persons classified as Transkei nationals lost their South African citizenship. In 1991, as part of negotiations between the South African government and the African National Congress (ANC) to reach a broad political settlement in South Africa, there were moves to reincorporate the "independent" black homelands into South Africa and abolish the apartheid laws that created them.

transmigration of souls Transmigration of souls, sometimes called metempsychosis, is based on the idea that a soul may pass out of one body and reside in another (human or animal) or in an inanimate object. The idea appears in tribal cultures in many parts of the world (for example, Africa, Madagascar, Oceania, and South America). The notion was familiar in ancient Greece, notably in Orphism (see ORPHEUS), and was adopted in a philosophical form by PLATO and the PYTHAGOREANS.

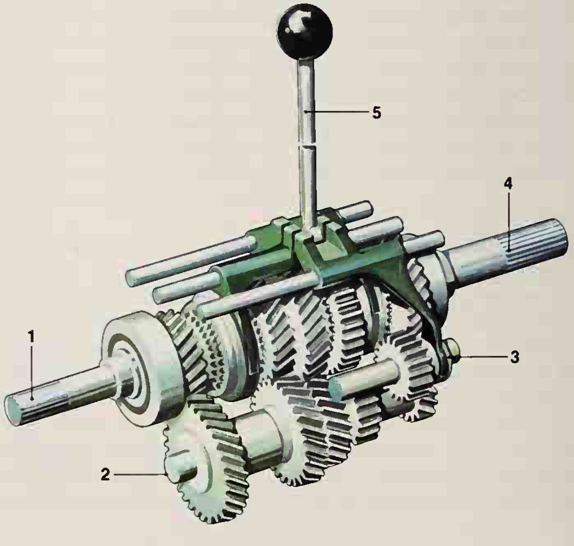
The most fully articulated doctrine of transmigration is found in HINDUISM. It does not appear in the earliest Hindu scriptures (the Rig Veda) but was developed at a later period in the UPANISHADS (*c.*600 BC). Central to the conception of human destiny after death was the belief that human beings are born and die many times. Souls are regarded as emanations of the divine spirit. Each soul passes from one body to another in a continuous cycle of births and deaths, their condition in each existence being determined by their actions in previous lives. Thus, transmigration is closely interwoven with the concept of KARMA (action), which involves the inevitable working out, for good or ill, of all action in a future existence. The whole experience of life, whether of happiness or sorrow, is a just reward for deeds (good or bad) done in earlier existences. The cycle of karma and transmigration may extend through innumerable lives; the ultimate goal is the reabsorption of the soul into the ocean of divinity from whence it came. This union occurs when the individual realizes the truth about the soul and the Absolute (Brahman) and the soul becomes one with Brahman. The Buddhist concept of samsara (a cycle of rebirth) often appears similar. The classical Buddhist doctrine of anatta ("no soul"), however, specifically rejects the Hindu view. The Buddhist position on the workings of karma is exceedingly complex.

The idea of transmigration has been propagated in the Western world by movements such as THEOSOPHY and by the more recent proliferation of Eastern religious cults.

transmission, automotive An automotive transmission is a device for transmitting power from the engine to the drive shaft, from which it is eventually carried to the wheels. The device must convert the power from the relatively fixed high angular velocity and low torque (turning force) of the engine crankshaft to the variable, usually lower speeds and higher torques needed at the wheels. The crankshaft is the part of the engine that converts the back-and-forth (reciprocating) motion of the engine pistons into rotary motion.

Generally, the transmission converts the engine power by means of a system of gears, providing a variety of gear ratios between the engine and the wheels. When the vehicle is starting from rest, the transmission is placed in first, or low, gear in order to produce a high torque at a low wheel speed. As the car speeds up, the driver shifts or the automatic transmission is shifted into a higher gear.

The gearbox is the part of the transmission that houses the gears. A modern gearbox has an input shaft (1) *from the engine, a layshaft* (2), *an idler* (3), *and an output shaft* (4). *All the gears are constantly in mesh with the exception of the idler gear, which is used for reverse. The gear wheels spin freely about the output shaft, but the wheels on the layshaft are fixed to it. A gear is engaged when the gearshift lever* (5) *locks a gear wheel on the output shaft into place. (Note that although the input and the output shafts are in a direct line, they are not connected.)*



With each higher gear, the drive shaft turns faster but with less power and torque. As an example, consider a simple three-speed transmission. When the car starts from rest in first gear, the gear ratio might be 3 to 1 (3:1). This means that the crankshaft turns three times to turn the drive shaft once. After the car gains some speed, the transmission is shifted into second gear, with a gear ratio of, say, 2:1. After a further increase in wheel speed, a shift is made into high, or third, gear. This is also called direct drive, because there is no gear reduction in the transmission: the gear ratio is 1:1, and the drive shaft turns at the same speed as the crankshaft.

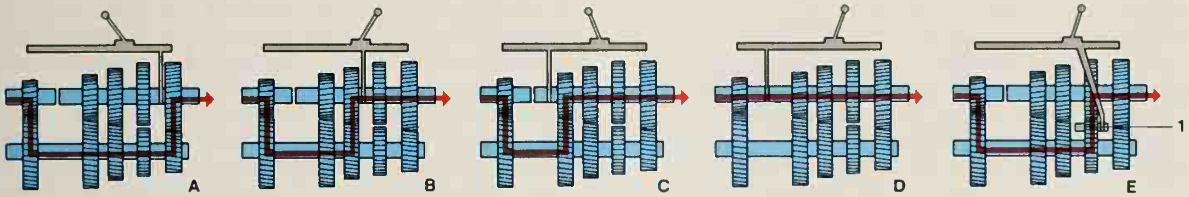
The two basic types of transmission are the manual type and the automatic transmission.

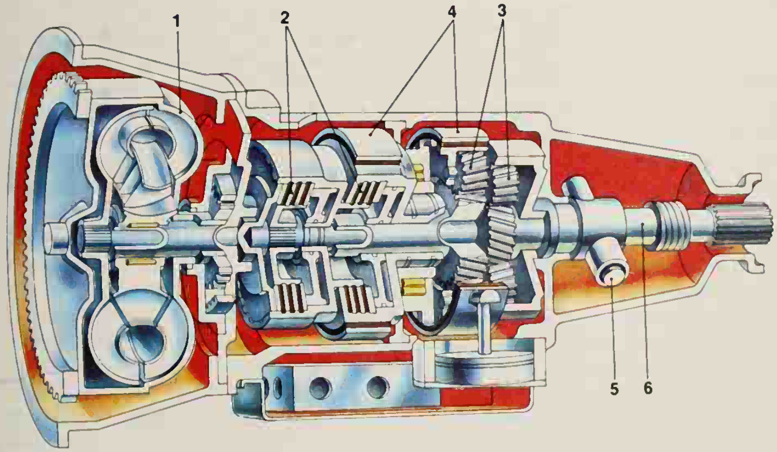
Manual Transmission. Early transmissions were all manually operated. There were two shafts, each with several gears of different sizes. One shaft could be moved, or shifted, with respect to the other in order to mesh, or engage, a gear on one shaft with a gear on the other.

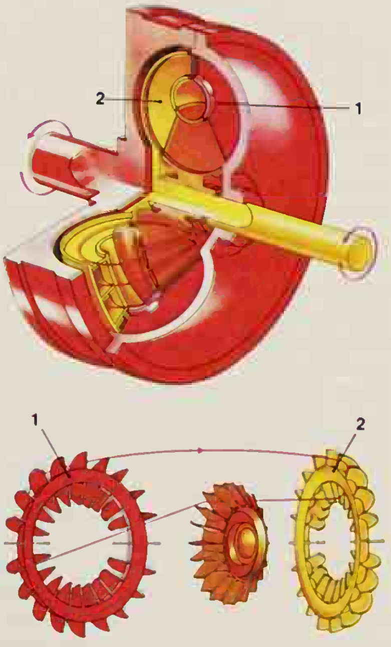
For most cars a transmission with three forward gears and one reverse gear is adequate. In some smaller cars with small engines, four- or five-speed transmissions are used to compensate for the lower torque available from the engine. Trucks designed to haul heavy loads may have as many as 20 forward speeds and four speeds in reverse. The part of the transmission that houses the gears is called the gearbox. A manual transmission has a clutch to disconnect the engine crankshaft from the gearbox while shifting gears. The driver shifts gears by manipulating a shift lever, which is connected to the transmission by a mechanical linkage.

In the newer synchromesh transmission, synchronizers allow the gear teeth to be in constant mesh, turning freely on their shafts. The selected combination of gears is first synchronized (the teeth on the two gears are brought to the same speed of rotation) and then locked together so that power is transmitted to the drive shaft and then to the DIFFERENTIAL.

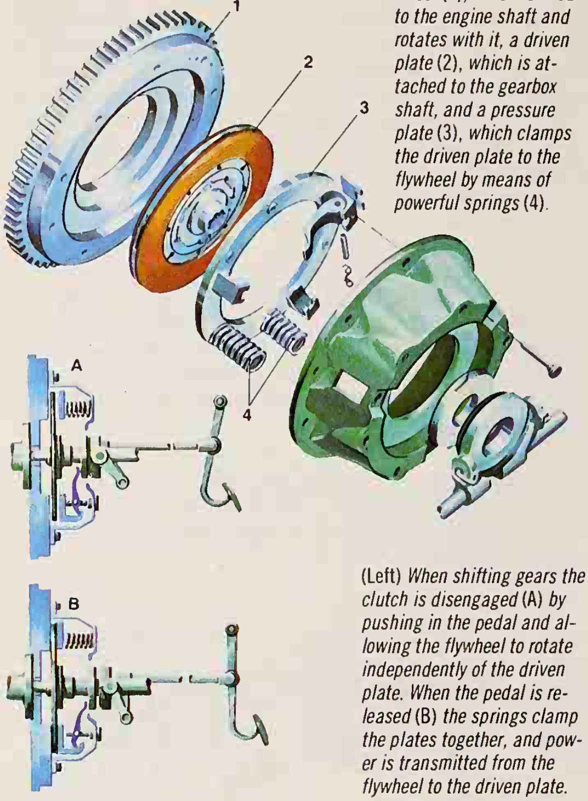
The various gear positions transmit engine power (indicated by red arrows). *Engine power on the spinning input shaft moves to the layshaft and from there to the output shaft (and the road wheels) by way of the output shaft's locked gear. In first gear* (A), *the largest gear is engaged for low-speed driving. Second* (B) *and third* (C) *gears use wheels of smaller size (closer gear ratios). The highest gear* (D) *is attained by directly coupling the input and output shafts. In reverse* (E), *the idler shaft* (1) *meshes the reverse gears on the layshaft and output shaft, whose direction then is reversed.*







(Above) *An automatic transmission passes power from the engine to the torque converter* (1) *and then to the various clutches* (2) *and epicyclic (planetary) gears* (3). *Different combinations of clutches and brake bands* (4), *automatically operated by the governor* (5), *select the appropriate driving gear. Gear selection depends on the vehicle's speed and engine load and on the position of the accelerator pedal, which is linked to the governor on the output shaft* (6). (Right) *A torque converter, which couples the engine and the gearbox, works much like two fans facing each other: if the blades of one fan are turning, the air current created will turn the blades of the other fan. Similarly, when the torque converter's engine-driven impeller* (1) *turns, with oil (instead of air) as the medium* (red arrows show direction of motion), *the turbine blades* (2) *will turn.*



A clutch consists of a flywheel (1), *which is fixed to the engine shaft and rotates with it, a driven plate* (2), *which is attached to the gearbox shaft, and a pressure plate* (3), *which clamps the driven plate to the flywheel by means of powerful springs* (4).

(Left) *When shifting gears the clutch is disengaged* (A) *by pushing in the pedal and allowing the flywheel to rotate independently of the driven plate. When the pedal is released* (B) *the springs clamp the plates together, and power is transmitted from the flywheel to the driven plate.*

Automatic Transmission. Automatic transmissions use a torque converter—to couple the engine and the gearbox. It is a form of fluid coupling in which one rotating member indirectly imparts a rotating motion to another rotating member on another shaft that is connected to the gearbox.

transmitter A transmitter, in RADIO communications, is a device used to impress information, such as voice or music, on a carrier wave and then to broadcast that wave through space in the form of ELECTROMAGNETIC RADIATION. The carrier wave, which has a definite frequency, is generated by an electrical OSCILLATOR and is a simple, repetitive sine wave. The oscillator is usually a crystalline material chosen for frequency stability. Information is superimposed on the carrier wave by altering one of the wave's basic characteristics in a process called MODULATION. The most common methods are AMPLITUDE MODULATION (AM) and FREQUENCY MODULATION (FM), in which, respectively, the amplitude and frequency of the carrier wave are altered. In AM the audio frequency, varying as the sound to be transmitted, is mixed with the carrier frequency in a manner that causes the carrier amplitude to vary at the same rate while the carrier frequency remains unchanged. In FM the frequency varies while the amplitude stays the same. Pulse-code modulation is a useful form of modulation for radio relay. In this system a series of identical pulses is used rather than a sine wave, and modulation is achieved by varying the pulse position or timing; with this method each repeater station can transmit noise-free pulses, even if the incoming signal has been degraded by static and other electrical noise.

In the transmitter the carrier is first generated and modulated at low power, say, a few watts. After modulation, the carrier signal is amplifed to the desired level of power, sometimes many kilowatts, depending on how great a coverage is involved, and then radiated from the transmitting ANTENNA. The signal is subsequently picked up by a RECEIVER and converted back to its original form.

transplantation, organ Organ transplantation has a short history, having originated in the mid-1950s with the work of researchers at the Peter Bent Brigham Hospital in Boston. They showed that dogs could survive in good health with one kidney that had been transplanted from the loin to another part of the body, an operation termed an *autotransplant*. This required skillful and expeditious surgery, but because the organ remained in the same individual there could be no rejection. These workers felt that a patient dying of kidney failure who was fortunate enough to have an identical twin might benefit from kidney transplantation, because identical twins arise from a single egg and therefore may be regarded in a biological sense as being the same individual.

Rejection. Unfortunately, grafts between individuals who are not identical twins are usually destroyed within a matter of days or weeks. The mechanism of this destruction was discovered by Peter Brian Medawar and his colleagues in the early 1940s to be an immune reaction of the body's lymphoid organs (lymph nodes, spleen, and bone marrow), similar in principle to the IMMUNITY resulting from exposure to the measles virus. A foreign graft, following recognition by the recipient's body, triggers a complicated response, called graft-versus-host disease, leading to rapid destruction of the graft. Cells produced from lymphoid organs produce antibodies that circulate in the blood and act specifically against the foreign organ. Other cells directly infiltrate the organ and proceed to damage its blood vessels and substance.

Tissue Typing. Research in the following years was directed at understanding and overcoming this rejection process. The aggressiveness of the immune response depends on the genetic gap between the donor and the recipient, and there is now much information on so-called tissue types, which are identified on white blood cells. These are analogous to the red-blood-cell groups important in blood transfusion. An important series of tissue antigens was discovered. Various components of this major histocompatibility complex (MHC) can be matched between donor and recipient. The Mendelian inheritance of the MHC means that there is a one-in-four chance of a given individual's having an MHC identical to that of his sibling. Transplants between MHC-matched siblings have excellent results, nearly as good as those between identical twins. A person inherits one MHC-containing chromosome from each parent, so that if a parent gives his or her child a kidney there will be expected at least a 50 percent matching of the MHC, and results are quite good. Grafts from unrelated donors do less well, even when taking into account matching for the MHC, suggesting that other important antigens are not covered by the current matching techniques.

Immunosuppression. Attempts to impair the activity of the lymphoid organs eventually led to the use of a combination of corticosteroid drugs with the antileukemia drug azathioprine (Imuran). These drugs became the central immunosuppressive regimen in patients in the early 1960s and have been responsible for the results mentioned above.

Another group of drugs, the CYCLOSPORINE family, has also become of major importance for immunosuppression. The drugs block the activity of lymphocytes called T-helper cells, which initiate the function of the cells that attack foreign tissues. Cyclosporines have potentially harmful side effects such as kidney damage or, in heart-transplant operations, increase of hypertension, and they impair the immune system's ability to fight off infectious organisms. Nevertheless, since they became available for clinical use in the early 1980s, they have dramatically increased survival rates in a variety of operations. A new drug called FK-506 has been found to be even more effective than cyclosporine in clinical experiments, without accompanying side effects.

Present Status and Future Outlook. Kidney grafting has been the most successful organ transplant thus far, because patients with kidney failure can be kept in good health by regular hemodialysis (see KIDNEY, ARTIFICIAL). For other organs no such equivalent luxury exists. Nevertheless, numerous kinds of transplant operations are performed, including heart, heart-lung, single-lung, bone-marrow, skin, and pancreas transferrals. Multiple-organ transplants are becoming more frequent, such as heart, liver, and kidney transplants. With the advent of cyclosporine the success rate for many of these operations has increased, but some others remain notably difficult—as, for example, pancreas operations.

Interestingly, in some transplant patients exceptionally good results have been obtained when the tissue match was poor. This may be the result of some specific desensitization that allows the recipient to accept the graft despite a strong biological difference, and it raises the possibility of deliberately inducing such acceptance. One route being explored since the 1980s is that of producing monoclonal antibodies (see ANTIBODY; GENETIC ENGINEERING) that attack specific T cells of the immune system without impairing the other T cells needed to fight infections.

transportation Transportation is the movement or conveying of persons and goods from one location to another. As human beings, from ancient times to the 20th century, sought to make their transport facilities more efficient, they have always endeavored to move people and property with the least expenditure of time, effort, and money. Improved transportation has helped make possible progress toward better living, the modern systems of manufacturing and commerce, and the complex, interdependent urban economy present in much of the world today.

This article will cover transportation from the historical viewpoint, with an emphasis on that of the United States; it concludes with a brief section on the future of transportation. The military aspects of transportation are covered in AIRCRAFT, MILITARY; ARMORED VEHICLE; and NAVAL VESSELS.

Early History

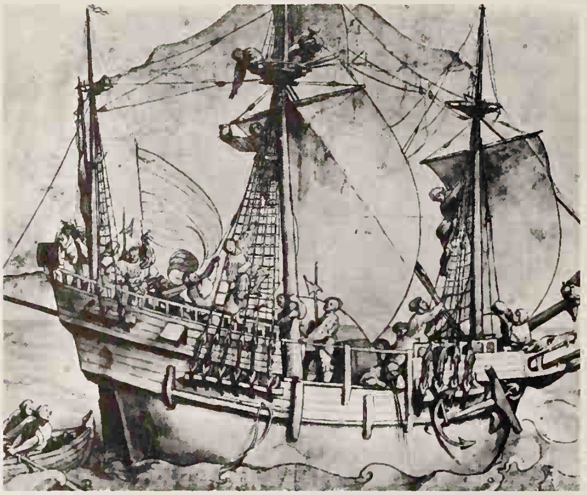
Land Transportation. Primitive human beings soon supplemented their own carrying of goods and possessions by starting to domesticate animals—training them to bear small loads and pull crude sleds (see ANIMAL HUSBANDRY). The invention of the WHEEL, probably in western Asia, was a great step forward in transport. As the wheel was perfected, crude carts and WAGONS began to appear in the Tigris-Euphrates valley about 3500 BC, and later in Crete, Egypt, and China. Wheeled vehicles could not use the narrow paths and trails used by pack animals, and early roads were soon being built. The Romans were the major builders of roads (see ROADS AND HIGHWAYS; ROMAN ROADS) in the ancient world, and at the peak of their power their well-constructed roads led from Rome to most parts of the expanding empire.

After the fall of Rome in the 5th century land haulage generally declined because the highways suffered from inadequate maintenance. Such improvements, however, as the horse collar (10th century), the addition of springs to coaches (mid-17th century; see COACH AND CARRIAGE), new methods of road construction, and the introduction of toll roads (18th century) all continued to ease and speed land travel.

Water Transportation. Water transportation also began early in human history. No doubt the first watercraft, the simple raft and the crude CANOE, both evolved from floating logs. Along the Tigris and Euphrates rivers the first boats were either hide-covered wicker baskets or dugout canoes, and in Egypt bundles of papyrus rushes were built into crude watercraft (see BOAT AND BOATING). Later the Cretans and Phoenicians built wooden SHIPS—oar-propelled GALLEYS with a single sail—that dominated trade on the Mediterranean.

The next major improvements in water transportation (see SHIPBUILDING) did not appear until late medieval times. The introduction of the compass (see COMPASS, NAVIGATIONAL) and rudder into Europe by 1300, and later the square sail, did much to improve ocean transportation. By the 15th century the nation-states of England, France, Portugal, and Spain were beginning to build three-masted ships, a vast improvement over earlier craft. Soon these countries were leaders in the Age of Exploration, which expanded ocean commerce well beyond the confines of the Mediterranean. Larger and more numerous sailing vessels improved commerce with the New World during the 17th and 18th centuries, and for a brief period in the 19th century U.S.-built clipper ships were actually faster than the early steamships.

CANALS were another important form of water transportation. The invention of the lock, which was in use in Eu-



(Above) *This drawing depicts a caravel, a small merchant ship often used for exploration during the 15th and 16th centuries.* (Right) *Supertankers such as the* Universe Island, *carry large volumes of liquid cargo, especially oil. Economic factors have dictated the construction of these vehicles—the largest mobile objects ever built—but serious concern has been expressed about the environmental problems they can cause if wrecked.*

rope before 1500, stimulated the construction of more and larger canals, such as the Canal du Midi in France.

Motorized Transportation

The greatest improvements in transportation have appeared in the last two centuries, a period during which the INDUSTRIAL REVOLUTION has vastly changed the economic life of the entire world.

Steamships. James Watt's STEAM ENGINE, perfected in the 1760s, was to do much more than provide power for many factories in England. By the end of the 18th century, French, Scottish, and American inventors were trying to apply the steam engine to navigation. In 1775 a Frenchman, Jacques Périer, built an early STEAMBOAT, and in 1807, Robert FULTON launched the steamboat CLERMONT on the Hudson River. In 1819 the steamer SAVANNAH crossed the Atlantic, and by the middle of the 19th century steam navigation was replacing the sailing vessel.

This new form of water transportation was particularly important in the broad Mississippi River valley of the United States. Hundreds of flat-hulled, tall-stacked western steamboats served the triangular territory reaching from Pittsburgh and Montana down to New Orleans. Until the 1850s the expansion of the western frontier was vitally tied to the steamboats serving the 25,700 km (16,000 mi) of navigable streams in the inland Mississippi River basin.

Railroads. Crude railways—horse-drawn wagons with wooden wheels and rails—had been used in English and European mines during the 17th century. Between 1797 and 1813, Richard TREVITHICK and other early inventors adapted primitive steam LOCOMOTIVES to the mine railway. In 1825, George STEPHENSON built and equipped the 32-km (20-mi) Stockton and Darlington Railway, the first public railway in the world to be powered by a steam locomotive, and a fever of RAILROAD building began in England.

Although it first appeared in England, the railroad had its most dramatic growth in the United States. By 1840 more than 4,800 km (3,000 mi) of railroad were already operating in the eastern states, a figure 40% greater than the total railroad mileage of Europe. By the eve of the Civil War the iron network in the United States was more than 48,000 km (30,000 mi) long, and the railroads of the western lines had nearly caught up with the ever-moving western frontier.

Following the Civil War several railroad lines were extended all the way to the Pacific coast (see TRANSCONTINENTAL RAILROAD), the first being the Union Pacific–Central Pacific, completed in 1869. Railroad construction in general was very rapid in the postwar decades; by 1890 the length of the U.S. rail system was 262,000 km (163,000 mi), and by 1916 it had reached an all-time high of 409,000 km (254,000 mi). Since World War I, however, the U.S. railroads have been in a decline, due partly to the rapid development of private automobiles, trucks, buses, pipelines, and airlines.

Motor Vehicles. The first new mode of transportation to challenge the railroad was the motor vehicle, which was made possible by the invention, in the 1860s and '70s, of the INTERNAL-COMBUSTION ENGINE. The AUTOMOBILE found its greatest popularity in the United States, where the first "horseless carriages" appeared in the 1890s. In 1908, Henry Ford introduced the MODEL T, which proved so popular that by 1914, Ford had adopted mass production methods to meet the demand. The Federal Highway Act of 1921 provided for primary highway routes across the length and breadth of the nation. The typical American family purchased its first car during the 1920s, and by 1930 there were 23 million passenger cars registered in the United States. Two hundred million motor vehicles had been produced in the nation within 70 years of their first appearance. The automobile thus became in many ways as important to the 20th century as the railroads had been to the 19th. During the same period intercity BUSES took over a large portion of commercial passenger travel, and trucks (see TRUCKING INDUSTRY) began carrying much of the nation's freight.

The introduction of mass-production methods enabled a large part of the American public to purchase their own automobiles. This development, however, led quickly to increasing problems of traffic flow, as seen in this 1917 view of 42d Street in New York City.

Multilevel intersections enable vehicles on converging roads to pass each other without hindrance. Such intersections and interchanges are built on expressways or at severe congestion points.

Pipelines. The first small pipelines (see PIPE AND PIPELINE) in the United States appeared in the oil fields of Pennsylvania just after the Civil War, and by 1900, John D. Rockefeller controlled a network of about 64,000 km (40,000 mi). By 1980, pipelines were carrying 23% of the nation's intercity freight traffic. In most years since World War II pipelines have moved as much freight as highway trucks.

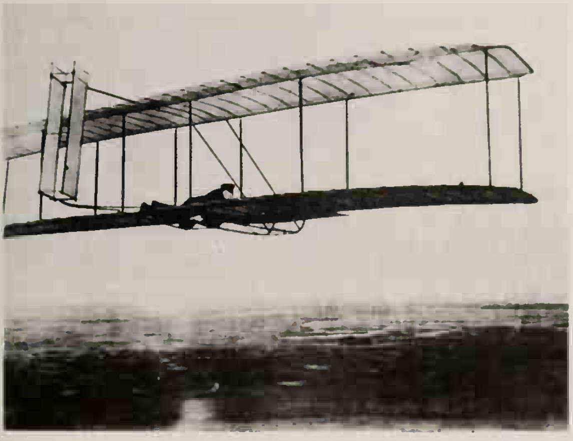
Aviation. At the turn of the century most people thought it preposterous that they would ever travel through the air in a machine heavier than the air itself. The airplane proved its potential in World War I, however, and in 1918 regular AIRMAIL service was started between Washington, D.C., and New York City. Air passenger traffic expanded quickly in the 1930s, and by 1939 air travel accounted for 2% of all commercial intercity travel. Air travel grew rapidly after World War II and in 1957 exceeded rail passenger travel for the first time. In 1980 nearly 83% of all commercial travel in the United States was by air (see AIRCRAFT; AVIATION).

The Future

Although the emphasis on fuel conservation waned in the 1980s, few doubt that the issue will emerge again when oil scarcities loom, as they did in the 1970s. Future possibilities include automobiles with far greater fuel efficiency and improved mass-transit systems. Both will occur not only in response to oil-supply disruption, but also as an answer to increasing demands for cleaner air.

Aviation experts anticipate the commercial development of hypersonic airplanes. The German *Saenger* will be both the first stage in a two-stage reusable space

Before the historic 1903 flight of their self-propelled airplane, Orville and Wilbur Wright conducted glider flights off Kill Devil Hill near Kitty Hawk, N.C. These flights enabled them to solve the problems of controlling a plane's motion.



Supersonic transports, such as the Concorde, provide the fastest commercial means of transportation. The Concorde can carry up to 130 passengers at twice the speed of sound (2,125 km/h; 1,320 mph).

The world's fastest train, France's TGV (an acronym from words that mean "train of great speed"), began operating in 1981. The train, powered by overhead electric lines, is capable of speeds of 370 km/h (236 mph). France hopes that such high-speed trains will form a network across Europe, signaling a new era in surface transportation.

launcher and—in a modified version—a commercial passenger liner that will travel at Mach 4.4 and at 30,500 m (100,000 ft). The experimental Soviet spaceplane Tupelov Tu 155, and the U.S. National Aerospace Plane, scheduled to make its first flight in the mid-1990s, will both be powered by liquid hydrogen.

See also: SPACE PROGRAMS, NATIONAL.

Transportation, U.S. Department of The U.S. Department of Transportation (DOT), established (Oct. 15, 1966) by act of Congress, is that part of the executive branch responsible for policies aimed at environmental safety and an efficient national transportation system that can also facilitate national defense. The secretary of transportation, who is a member of the president's cabinet, and the secretary's staff are responsible for overseeing more than 30 agencies. The major divisions of the DOT are the U.S. COAST GUARD, FEDERAL AVIATION ADMINISTRATION, the Federal Highway Administration, the Federal Railroad Administration, Urban Mass Transportation Administration, Maritime Administration, St. Lawrence Seaway Development Corporation, and the National Highway Traffic Safety Administration.

transposon Transposons are segments of DNA that can change locations among the chromosomes and extrachromosomal DNA molecules of bacteria and higher organisms (see GENETIC CODE). A transposon is replicated along with the rest of the chromosome in its new location, and it is transmitted to all daughter cells during subsequent cell divisions. Each transposon contains a gene for the enzyme transposase, which permits it to move successfully from one location to another. In addition, both ends of a transposon terminate in a special sequence of DNA bases, called an insertion sequence, that facilitates its incorporation into its new location.

A number of genetic effects can accompany the insertion of a transposon within or near a gene. The transposon may prevent the gene from functioning, thereby acting as the equivalent of a mutation. On the other hand, insertion of a transposon into a chromosome may result in the deletion or rearrangement of part of the chromosome. In bacteria, transposons have been found to carry genes for drug resistance, toxin production, and the breakdown of certain compounds.

transsexual see SEX REASSIGNMENT

transubstantiation see EUCHARIST

transuranium elements [trans-yur-ay'-nee-uhm] The transuranium ELEMENTS are the chemical elements (see PERIODIC TABLE) that have atomic numbers greater than uranium (93 and higher). The transuranium elements have only radioactive ISOTOPES because their large nuclei are unstable. All have half-lives much shorter than the age of the Earth and (with the exception of trace amounts of NEPTUNIUM and PLUTONIUM) are not found in nature. Synthesis of these elements began in 1940. Elements 93–103 are members of the ACTINIDE SERIES, and those with an atomic number of 104 and higher are called SUPERHEAVY ELEMENTS.

A claim for the discovery of a transuranium element requires a valid nuclear reaction and a means of chemical identification. Because the half-lives of the heaviest isotopes are no more than a few minutes or seconds, ingenious methods of rapid synthesis, isolation, and identification have had to be developed. The chemical identification of these short-lived isotopes is often based on the discovery of just a few atoms. MENDELEVIUM, for example, was identified by the separation of five atoms, using an ion-exchange column and assuming properties analogous to those of fermium (the nearest actinide element) and thulium (the lanthanide homologue of mendelevium).

Transvaal [tranz-vahl'] Transvaal, the northernmost, mineral-rich province of South Africa, has an area of 283,917 km^2 (109,625 mi^2). Of its population of 7,532,179 (1985), about 75% are black and 25% are white. PRETORIA is the capital, JOHANNESBURG the largest city. The economy is based on agriculture, diversified industry, and the region's vast mineral resources, which include gold, diamonds, coal, uranium, platinum, and chromite. The WITWATERSRAND region contains the world's richest gold field. Kruger National Park is in the northeast.

Originally inhabited by BANTU tribes, Transvaal was settled in 1838 by AFRIKANERS, who founded the South African Republic in 1856. Britain annexed the region in 1877, which led to disputes over the Afrikaners' sovereignty and eventually to the SOUTH AFRICAN WAR (1899–1900). Transvaal became a province of the Union of South Africa in 1910.

transverse wave see WAVES AND WAVE MOTION

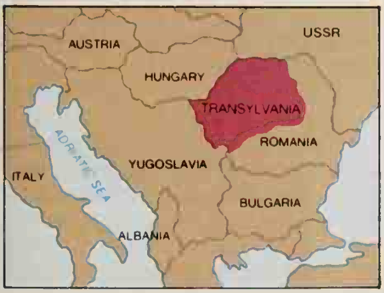
transvestism Transvestism, also known as cross-dressing, is a sexual variance wherein the individual, usually male, experiences sexual satisfaction from dressing in clothing generally worn by the opposite sex. Most transvestites are heterosexual and are not interested in changing, by way of sex-transformation surgical procedures, into the opposite sex.

The incidence of transvestism in the population is probably less than 1 percent. Apart from their cross-dressing, which may be only occasional, transvestites tend to be conventional in their sexual habits and often marry. The causes of transvestism are not definitely known. Psychological theories frequently suggest that faulty or abnormal parent-child interactions are at the root of this variance. Psychotherapy, including behavior-modification techniques, can be effective in treating transvestism.

Transylvania [tran-sul-vay'-nee-uh] Transylvania (Romanian: Transilvania; Hungarian: Erdély) is a hilly region in northwestern Romania, enclosed on the east and south by the Carpathian Mountains and Transylvanian Alps and on the west by the Bihor Mountains. The main cities are Cluj-Napoca, Braşov, and Sibiu, but the population is mostly rural and agricultural. Forestry is also important. Minerals include lignite, iron, copper, and natural gas, and steel and chemicals are manufactured.

Ethnic Romanians form the majority of the population; significant minorities include Hungarians (Magyars) and, to a lesser extent, Germans. The Szeklers, or Szekelys, are a Magyarized people of disputed origin.

Transylvania was at the center of the Roman province of Dacia after AD 106. From the 11th to the 16th century Transylvania was ruled by Hungary; it then became an autonomous principality of the Ottoman Empire. In 1699 it came under the Habsburgs as part of Hungary. A Romanian national revival took place there in the late 19th century, and in 1920 the historic Transylvania was incorporated into Romania. Northern Transylvania was transfered to Hungary in 1940 and restored to Romania in 1945. In the late 1980s a conflict arose between Romania and Hungary over alleged Romanian mistreatment of its Hungarian population.



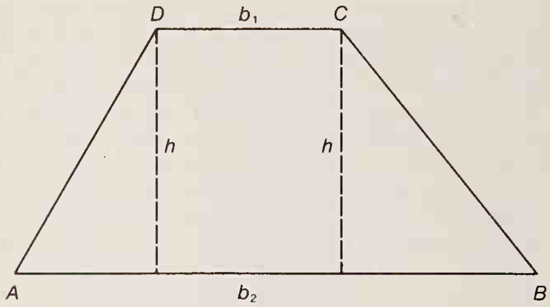
Romania's historic region of Transylvania has long been home to diverse peoples—including Magyars, Szeklers, and Germans, in addition to Romanians.

Transylvania Company The Transylvania Company, first organized as the Louisa Company in 1774, was an association of North Carolina land speculators who proposed to colonize and exploit a huge area illegally obtained from the Cherokee Indians—the land mass between the Kentucky River and the highlands south of the Cumberland (now part of Kentucky and Tennessee). Richard Henderson, a leader of the company, dispatched Daniel Boone to blaze a trail (the Wilderness Road) and followed him to the Kentucky fort that was later called Boonesborough. Henderson's attempt to establish a proprietary colony in Boonesborough was resisted by many of the settlers and thwarted by the states of Virginia and North Carolina, whose chartered limits encompassed Transylvania. In compensation for this loss and for the labor of opening the frontier, Henderson was given 200,000-acre (about 81,000-ha) tracts in both Kentucky (by Virginia) and Tennessee (by North Carolina).

trap door spider Trap door spiders construct burrows lined by their silk and closed by a hinged door of silk, moss, and soil. There they lie in wait for passing prey, usually an insect; when the prey touches silken threads radiating out on the ground near the door, the spiders quickly open the door and seize it. Closely related to tarantulas, trap door spiders make up the family Ctenizidae. They are generally small, are harmless to humans, and are found in many warm climates. They also use their burrows for protection and as nest sites, the female spinning her egg sac for about 300 eggs in the burrow.

The predatory trap door spider is well equipped for digging, having, in addition to its interior fangs, a row of exterior teeth to assist in soil removal. Its burrow may extend downward as far as 25 cm (10 in), providing it with a secure spot from which to ambush its prey.

trapezoid [trap'-uh-zoyd] A trapezoid is a four-sided plane figure that has two parallel sides. The parallel sides are called the bases, and the nonparallel sides are called



legs. If the legs are of equal length, the trapezoid is an isosceles trapezoid. The perpendicular distance between the bases is called the altitude; the area of a trapezoid is equal to half the sum of the bases times the altitude.

Trappists [trap'-ists] Trappists is the popular name for members of the Roman Catholic order of CISTERCIANS of the Strict Observance (O.C.S.O. or O.C.R.), which traces its beginnings back to the reforms introduced (1664) by Armand Jean le Bouthillier de Rancé (1626–1700) at the monastery of La Trappe near Séez, France. He stressed the penitential aspect of monasticism—little food, no meat, hard manual labor, and strict silence. These measures were adopted by other Cistercian monasteries.

In the mid-20th century the Trappists increased in membership, particularly in the United States. One influential member was the writer Thomas Merton. The Trappist monks and nuns, who wear a white habit with black scapular, now have about 70 abbeys worldwide.

Traubel, Helen [trow'-bul] Helen Traubel, operatic and concert soprano, b. St. Louis, Mo., June 20, 1899, d. July 28, 1972, was the first American-born and trained artist to sing the Wagnerian roles of Isolde and Brünnhilde at the Metropolitan Opera. After her 1939 Metropolitan debut as Sieglinde in *Die Walküre,* she alternated with Kirsten Flagstad in Wagnerian roles until the latter's departure in 1941. Traubel made her London debut in 1953. A series of nightclub engagements led to a dispute with and her resignation from the Metropolitan Opera, but she continued to perform actively on radio and in films.

traveler's check Traveler's checks were devised by the American Express Company in 1891 to protect travelers who might otherwise carry large amounts of cash that could be lost or stolen. These checks are sold, usually for a small handling fee, by banks or express agencies in different denominations and in most of the world's major currencies. Traveler's checks are accepted as payment almost everywhere in the world; they can also be converted into cash and are redeemable in foreign currencies according to the prevailing rate of exchange.

traveling-wave tube The traveling-wave tube is a specialized ELECTRON TUBE capable of amplifying a MICROWAVE signal. An electron gun at one end of the cylindrical tube generates electrons that are confined into a narrow beam by an electromagnetic coil wound around the circumference of the tube. Microwave energy entering the tube near the electron gun travels by means of a waveguide along the path of the electron beam, where it modulates the beam by forcing the electrons in the beam to group into bunches. The amplified microwave energy then passes out the far end of the tube. The electron beam leaves the tube through a collector.

Traveling-wave tubes are efficient and can amplify signals over a wide range of frequencies. They are used in microwave transmitters and receivers for radar systems, in spacecraft, and in other applications. Other important microwave tubes are the klystron and the MAGNETRON.

Traven, B. [trah'-ven] B. Traven, or Ben Traven, was the pseudonym of Berick Traven Torsvan, b. Chicago, Mar. 5, 1890, d. Mar. 27, 1969. Among his dozen novels, written in German, *The Treasure of the Sierra Madre* (1927; Eng. trans., 1934)—a grimly ironic story of human greed that was made into a classic film by John Huston in 1948—is easily the most famous. Traven guarded his privacy so closely that even his identity remained a mystery until after his death. He resided in Germany during World War I and subsequently moved to Mexico.

travertine see SINTER

travesty see BURLESQUE AND TRAVESTY

Traviata, La see VERDI, GIUSEPPE

Travis, William B. [trav'-is] Both lawyer and soldier, William Barrett Travis, b. Edgefield, S.C., Aug. 9, 1809, d. Mar. 6, 1836, was a hero of the TEXAS REVOLUTION. He took part in the capture of San Antonio in December 1835 and led the defense of the ALAMO against Mexican siege from Feb. 23 to Mar. 6, 1836. Travis died when the entire garrison was massacred.

travois [trav-oy'] A travois is a drag frame consisting of two long poles, the front tips tied together on the back of a dog, the stub ends splayed out and dragging on the ground, connected in mid-length with a piece of netting or skin. It was used among the Plains Indians to carry a load of up to 27 kg (60 lb) across the Plains in the course of their migrations. The load might consist of a quarter of a bison, firewood, or a baby or child. When the Indians acquired the horse, they used a much larger version of the travois with long TEPEE poles, which could carry an injured person or other larger loads.

trawler see FISHING INDUSTRY

treadmill A treadmill is a machine in which a wheel oriented with a horizontal axis of rotation is turned by persons or animals walking, or treading, on boards arranged about the periphery of the wheel. This arrangement permits the multiplication of the applied force, as in a lever. Various types of treadmills were used in ancient times, both to lift water and to grind grain.

Treadmills attached to cranes were used to lift heavy objects from Roman times, and perhaps earlier, through the late Middle Ages in Europe. Treadmills came to be used as instruments of prison discipline, especially during the 16th and 17th centuries. Similar types of mechanisms have been developed for operation by different types of animals in sideshows, at the circus, and as novelty items.

treason Treason, a crime against the state to which allegiance is owed, consists of attempting to overthrow the government or betraying it into the hands of its enemies. Under English law *high treason* was once so broad a term that it was used until the 19th century to justify punishing all sorts of persons who were judged as enemies of the monarch. The U.S. Constitution narrowly defines treason and specifically declares: "No Person shall be convicted of Treason unless on the Testimony of two Witnesses to the same overt Act, or on Confession in open Court." This constitutional statement was strictly followed by Chief Justice John Marshall in the 1807 trial of Aaron BURR, who was charged with treason for allegedly plotting to establish an independent republic in the Louisiana Territory but who was acquitted because the prosecution could not prove Burr guilty of "an overt act of levying war." Less than 40 federal prosecutions for treason have occurred, and only once in its history has the U.S. Supreme Court sustained a conviction for treason (*Haupt* v. *United States,* 1947). Many state constitutions have treason provisions, but only two persons have been successfully prosecuted by states: Thomas Dorr (see DORR'S REBELLION) and John BROWN.

Treasure Island *Treasure Island* (1883) is a classic adventure story by Robert Louis STEVENSON. The narrator, young Jim Hawkins, describes a hunt for buried treasure, which involves a voyage on the schooner *Hispaniola* and a clash with pirates led by the notorious one-legged Long John Silver. Other memorable characters include the blind villain, Pew, and the marooned sailor, Ben Gunn. Several film versions have been made.

Treasury, U.S. Department of the The U.S. Department of the Treasury is the department of the executive branch of government that oversees the nation's finances. The department was created in 1789, and its first secretary was Alexander Hamilton.

The secretary of the treasury is the second-ranking officer (after the secretary of state) in the president's cabinet. He or she is the president's chief advisor on fiscal affairs and is responsible for managing the public debt. The law requires the secretary to report each year to the Congress on the government's fiscal operations and its financial condition. The secretary is also involved in financial dealings with other nations.

The Treasury Department's operating bureaus include the COMPTROLLER OF THE CURRENCY, who supervises national banks; the U.S. Customs Service, which collects taxes on goods brought into the country from abroad; the Bureau of Engraving and Printing, which produces currency, bonds, Federal Reserve notes, and postage stamps; the Bureau of Government Financial Operations, which is responsible for money management; the INTERNAL REVENUE SERVICE, which collects taxes; the United States Mint, which manufactures coinage; the Bureau of Alcohol, Tobacco and Firearms, which is a law enforcement agency; and the SECRET SERVICE, which protects top U.S. officials and presidential candidates and enforces laws against counterfeiting.

treaty A treaty is a formal agreement that regulates relations between two or more sovereign states. Treaties are known to have existed since before 3000 BC. They are mentioned in the Old Testament and in Greek and Roman literature. Treaties may pertain to political matters, such as alliances or the cessation of armed conflict; commerce, such as tariffs or navigation; legal issues, such as extradition or copyright agreements; and matters of confederation and integration, as in the setting up of international and supranational organizations.

In republics the power to negotiate treaties usually lies within the province of the chief executive. In the United States, the Department of State, under the authority of the president, usually assumes the task of formulating a treaty. A treaty goes into effect only after it has been ratified in accordance with each nation's requirements. Ratification in the United States requires approval by two-thirds of the Senate. (The president, however, may make executive agreements that do not need Senate approval.) In Britain ratification depends on acceptance by Parliament and the crown.

A treaty may be terminated either by the consent of all parties concerned or if a clause in a treaty provides an expiration date or permits cancellation by either party after due notice.

Treaties can be—but are not necessarily—terminated or suspended by the outbreak of war between warring parties, except for treaties regulating the conduct of war. Failure of one party to observe the terms of a treaty, moreover, entitles the other party to abrogate it.

In the United States, states may not make treaties, and treaties constitute part of the supreme law of the land, taking precedence over all laws and state constitutions. Early in its history the United States made many treaties with the American Indians. These treaties dealt with the Indian tribes as foreign governments and are legally binding. Congress declared, however, in 1871 that the Indians were no longer to be regarded as independent nations; thereafter treaties were no longer necessary to regulate relations with the Indians.

treble *Treble* is a term usually used to refer to children's voices of high range, whereas the equivalent high voice of an adult woman is called SOPRANO. It is also a name given to certain high-pitched instruments, such as the treble recorder and treble viol; to the uppermost part of a musical composition; to the highest pitches as opposed to the lower, BASS, parts; and to the name of a CLEF, also called the G clef. The term, however, is often loosely used to characterize women's voices and high-pitched instruments in general.

Treblinka [treb-link'-uh] Treblinka was a concentration camp 80 km (50 mi) from Warsaw, Poland, used by the German Nazis in their program of exterminating the Jews. First established by the Germans as a slave labor camp in 1941, Treblinka was turned into a death camp early in 1942. From July to September 1942, 300,000 Jews were deported from Warsaw to Treblinka. In mid-May 1943 the entire population of the Warsaw ghetto was dispersed and transported to Treblinka and other death camps. By July 11, 1945, when the armies of the USSR entered Warsaw, 800,000 Jewish men, women, and children had been put to death at Treblinka.

tree A tree is generally defined as an erect PLANT with a single woody stem capable of reaching heights of at least 6–8 m (20–25 ft) at maturity. Depending on environmental conditions and age, however, some tree species may exhibit growth forms characteristic of SHRUBS and vines. Trees dominate the ecosystem because they grow to large sizes and live for many years. For example, the coast redwood, *Sequoia sempervirens*, attains the greatest height (112 m/368 ft) of any tree species. The Sierran redwood, *Sequoiadendron giganteum*, has the largest diameter, reaching 9 m (30 ft). Although relatively short, the bristlecone pine, *Pinus aristata*, is one of the most long-lived trees known, the oldest documented specimen thought to be about 4,900 years old, which far exceeds the life span of 100 to 250 years of most trees.

Classification

Trees are classified in a variety of ways but are most commonly divided into two groups on the basis of their reproductive structures. The GYMNOSPERMS (meaning naked seeds), evolutionarily the more primitive group, bear seeds on modified leaf structures called scales, which are often aggregated into cones. They include such well-known trees as the pines (*Pinus*), firs (*Abies*), spruces (*Picea*), and hemlocks (*Tsuga*). The gymnosperms are often referred to as CONIFERS, EVERGREENS, needle-bearing trees, or softwoods. These designations may be misleading, however. Cycads (*Cycas, Zamia*) are classified as gymnosperms but have conelike reproductive structures, not true cones, and hence are not conifers. Some gymnosperms, such as the ginkgo, *Ginkgo biloba*, have broad leaves, instead of needles. The larches (*Larix*) are not evergreens but shed their leaves during the winter. Also, some gymnosperms have WOOD of considerable hardness.

The other major group of trees, the ANGIOSPERMS, have flowers and bear their seeds enclosed in a FRUIT, which is the ripened ovary of a FLOWER. Representative flowering trees include the oaks (*Quercus*), beeches (*Fagus*), poplars (*Populus*), birches (*Betula*), cherries (*Prunus*), tulip trees (*Liriodendron*), elms (*Ulmus*), ashes (*Fraxinus*), and maples (*Acer*). Angiospermous trees are sometimes referred to as deciduous trees (those which lose their leaves for part of the year) or hardwoods. Not all angiospermous trees are deciduous, however; many species in the genus *Eucalyptus* are evergreen. Some flowering trees have wood that is relatively soft.

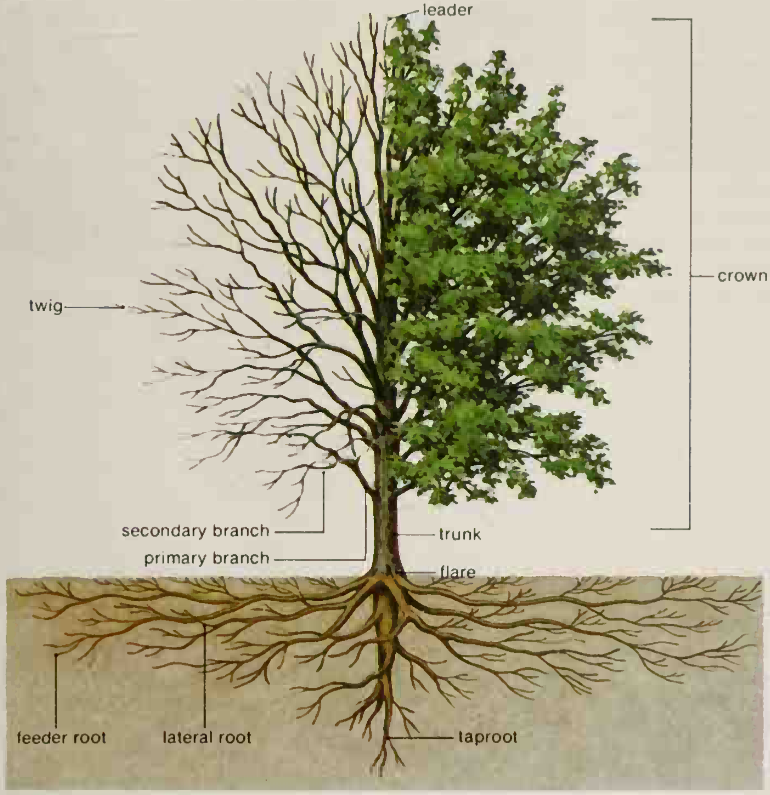
Structure and Function

Trees have four major structural components: the stem, or trunk, including branches and twigs; leaves; roots; and reproductive structures.

Stem. The stem supports the tree and provides pathways for the upward transport of water and nutrients and the downward movement of carbohydrates. Very little of the stem actually consists of elements of living cells. Elements of the stem are arranged concentrically in cross section. The outer BARK consists mostly of dead cells and protects the living tissue of the stem. The inner bark, or phloem, is composed of living cells through which various organic materials are transported throughout the stem and root system. A thin cambial layer, which consists of meristematic tissue, or undifferentiated cells that are capable of reproducing themselves, is located at the interface of the bark and woody stem. This layer, called the cambium, generates phloem to the outside and xylem (wood) to the inside. The xylem is differentiated into sapwood and heartwood. The sapwood, located next to the cambium, consists primarily of dead cells that are used to transport water and nutrients up through the stem to the crown, or the upper portion of the stem, branches, and leaves. In older trees the inner core of wood consists of heartwood, which is composed of dead cells that contain deposits of various chemicals and is no longer functional in the movement of water.

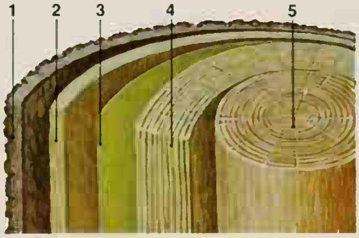
Leaves. Leaves are the sites of food production in most trees. Chlorophyll makes the leaves appear green in color. Leaves come in a wide variety of sizes and shapes, from large compound structures (as in walnuts, *Juglans*, and hickories, *Carya*) to needles (as in pines) and tiny scales (as in junipers, *Juniperus*). The life span of leaves also varies greatly from less than 1 year to more than 20 years in some species. Leaves are important as sites for gaseous exchanges such as the absorption of carbon dioxide (CO_2), which is the gas used to produce carbohydrates in PHOTOSYNTHESIS, and transpiration (loss of water vapor), which is an important process in maintaining the flow of water from the root system to the crown of the tree. Leaves have small openings or pores, called STOMATA, which are the sites for most of these exchanges.

Roots. The root system consists of one or more large, woody roots and an extensive network of fine roots. The large roots anchor the tree, and the fine roots carry out the critical function of absorbing water and nutrients from



(Left) *A white oak, with its roots and half of its branches exposed, illustrates the external anatomy of a tree. The root system anchors the tree and supplies it with water and nutrients from the soil. The trunk, typically braced by a swelling, or flare, at its base, tapers to its highest branch, the leader, and supports the branches, twigs, and leaves. The leaves, exposed to sunlight, produce food for the entire tree by means of photosynthesis.*

(Below) *A cross section of a tree trunk reveals several concentric layers. Outer bark* (1), *composed of dead cells, protects the inner layers. Phloem* (2), *or inner bark, conducts food from the leaves to the rest of the tree. Cells of the cambium* (3) *divide to produce phloem and, on the inner side, wood (xylem). Sapwood* (4), *a mixture of living and dead cells, carries water and nutrients up the trunk. Heartwood* (5), *composed of dead cells, adds strength.*



the soil. Water absorbed by the fine root system moves through the coarse roots, stem, and branches to the leaves. The fine root system typically consists of both small, nonwoody root hairs and mycorrhizae. Mycorrhizae are complex structures that incorporate both fungal strands, or hyphae, and root hairs. These structures greatly increase the absorptive capabilities of the tree's root system, and the fungus receives carbohydrates and other complex organic molecules manufactured by the tree. Many fungal species form this symbiotic relationship with trees, and, in turn, most tree species benefit by having mycorrhizae (see SYMBIOSIS). Symbiotic nitrogen-fixing bacteria living in the roots of some trees, such as alder (*Alnus*), and of some legumes provide usable nitrogen compounds to the host plant; the bacteria obtain food from the tree in return.

Reproductive Structures. In most gymnosperms the seed-bearing structure is the conelike strobilus. Male, or pollen-producing, and female, or ovuliferous, strobili are borne on different branches of the same tree. In angiospermous trees, the ovary of the flower contains the ovules that become seeds following pollination and fertilization. Perfect flowers have both male and female parts; imperfect flowers are either male or female. Many trees, such as beeches, which have male and female flowers on the same plant, are monoecious. Dioecious trees, such as willows (*Salix*), have male and female flowers on separate individuals.

Growth

Growth of a tree occurs from division of cells in the meristematic tissue in the cambium and the tips of the branches and roots. Cambial cell division results in an increase in tree diameter. The xylem cells added to the stem usually differentiate into thin-walled springwood and thick-walled summerwood that produce the annual rings visible in cross sections of most tree trunks from temperate areas. The meristems associated with the crown produce elongation of the branches, resulting in increases in tree height.

Trees are potentially immortal because meristematic tissues are retained throughout the life of the tree. Death usually results from some environmental agent, such as fire, wind, lightning, drought, or human cutting, or from a biological cause, such as disease or insect attack. As a tree ages it may become more susceptible to insect pests or diseases, such as bark beetles or fungal root rots, which contribute directly or indirectly to its death. Most trees actually die of several causes.

Ecology and Distribution

Moisture, temperature, and nutrient conditions are the most important environmental factors affecting the establishment and growth of tree species. Forests are widely distributed in the temperate and tropical regions of the world and are a reflection of favorable moisture and temperature regimes in these areas (see FORESTS AND FORESTRY). Some notable forest regions in North America are the pine forests of the southeastern states, the deciduous hardwood forests of the northeastern and Great Lakes region, the mixed coniferous forests of the Rocky Mountains and Sierra Nevada, and the dense coniferous forests of the Pacific Coast.

Tree species tolerate different environmental conditions. Trees grow more slowly, attain smaller dimensions, and are often more widely spaced in cold or arid regions. Cold temperatures, short growing seasons, and heavy snows prevent the growth of trees at high elevations and high latitudes. Moisture stress typically limits tree growth at lower timberlines, such as those adjacent to grasslands or deserts.

Importance

Trees are valuable to humankind for many products and amenities. Many trees are major sources of food, primarily as fruits and NUTS; also, sugar is derived from the sap of some trees. Wood is a significant source of fuel for heating and cooking, particularly in developing countries. Construction materials from wood include LUMBER, plywood, and particle board. Wood is the main source of fiber for the production of pulp and PAPER. Trees are a primary or secondary source for many chemical products. Some fibers, such as RAYON, are produced from wood pulp. The bark of some tree species is the major source of tannins. Other chemicals are harvested directly from living trees, such as RUBBER and various resins, which are then refined to such products as TURPENTINE.

Trees also provide numerous services. They protect soils from erosion and help maintain high-quality water supplies. Tree root systems make a key contribution to soil stability. Living trees create valuable wildlife habitats. Standing dead trees, often called snags, also serve as animal habitats. Downed trees are important in conserving and cycling nutrients, in reducing soil erosion, as wildlife habitats, and as nursing sites for the establishment of other plants. Trees create shelterbelts in agricultural regions and attractive and effective barriers in urban areas, and also contribute aesthetically to many natural and domesticated landscapes.

tree frog Tree frogs are members of the family Hylidae, which consists of more than 450 species, including true tree frogs and peepers (genus *Hyla*), cricket frogs (*Acris*), and chorus frogs (*Pseudacris*). Tree frogs are found on all temperate and tropical continents except Australia. They range in size from diminutive (less than 2.5 cm/1 in long) to large frogs. Most are good jumpers and are arboreal (living in trees), with climbing aided by toe disks and cartilages between the ultimate and penultimate phalanges. A few genera (*Acris, Pseudacris*, and *Limnaoedus*), however, have reduced toe disks and tend to be terrestrial. Most tree frogs lay eggs in water, but some (such as *Gastrotheca* and *Hemiphractus*), carry their eggs on their backs; a few (for example, *H. rosenbergi* and *H. faber*) build mud nests near water, and still others (phyllomedusines) deposit their eggs on overhanging leaves, the tadpoles later falling into the water.

The European green tree frog has discs on its digits that enable it to climb trees. It is found from Europe to Central Asia.

tree of heaven see AILANTHUS

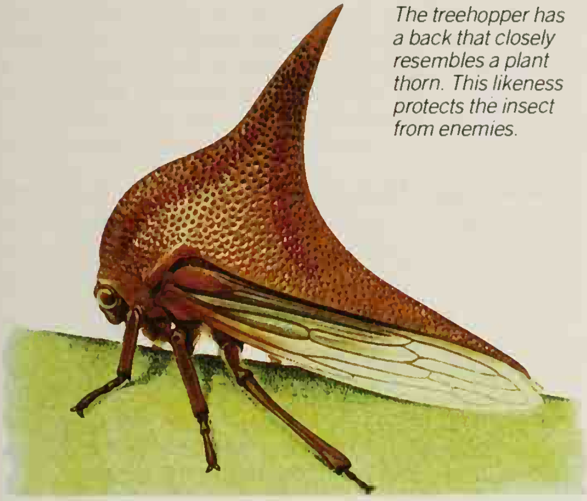
tree-ring dating see DENDROCHRONOLOGY

tree shrew A tree shrew is a small, squirrel-shaped mammal found in forested areas of India, southern China, southeastern Asia, Indonesia, and parts of the Philippines. About 15 species—10 typical tree shrews of the genus *Tupaia*; the Indian tree shrew, *Anathana*; the smooth-tailed tree shrews, *Dendrogale*; the Philippine tree shrew, *Urogale*; and the small, pen-tailed tree shrew, *Ptilocercus*—make up the family Tupaiidae. Some zoologists classify tree shrews as primates because of their relatively large brains, eyes in orbits surrounded by bone, and other features; others classify them with shrews and moles as insectivores. Tree shrews are usually less than 45 cm (18 in) in length—about half of which is the tail—and weigh less

The common tree shrew has a squirrellike body approximately 20 cm (8 in) long and a bushy tail of about the same length. It is primarily a ground dweller that nests in tree roots or in fallen trees.

than 0.5 kg (1 lb). They have long snouts, squirrellike ears, and five fingers and five toes, each with a sharp claw. The fur is usually brownish. Swift runners and good climbers, tree shrews feed mainly on fruits and insects.

treehopper Often bizarrely shaped, the treehoppers are small jumping insects of the family Membracidae and are related to leafhoppers and spittlebugs. Rarely longer than 10 mm (0.4 in), they usually appear humpbacked; the pronotum (the body part just behind the head) extends back over the body, sometimes assuming a thornlike shape. Common in vegetation, treehoppers can damage crops by sucking the juice out of young seedlings. The buffalo treehopper damages apple trees by laying its eggs in the bark.



The treehopper has a back that closely resembles a plant thorn. This likeness protects the insect from enemies.

Trent, Council of The Council of Trent, the 19th ecumenical council of the Roman Catholic church, was held at Trent in northern Italy between 1545 and 1563. It marked a major turning point in the efforts of the Catholic church to respond to the challenge of the Protestant REFORMATION and formed a key part of the COUNTER-REFORMATION. The need for such a council had long been perceived by certain church leaders, but initial attempts to organize it were opposed by FRANCIS I of France, who feared it would strengthen Holy Roman Emperor CHARLES V, and by the popes themselves, who feared a revival of CONCILIARISM. The council eventually met during three separate periods (1545–47, 1551–52, 1562–63) under the leadership of three different popes (PAUL III, Julius III, PIUS IV). All of its decrees were formally confirmed by Pope Pius IV in 1564.

In the area of religious doctrine, the council refused any concessions to the Protestants and, in the process, crystallized and codified Catholic dogma far more than ever before. It directly opposed Protestantism by reaffirming the existence of seven sacraments, transubstantiation, purgatory, the necessity of the priesthood, and justification by works as well as by faith. Clerical celibacy and monasticism were maintained, and decrees were issued in favor of the efficacy of relics, indulgences, and the veneration of the Virgin Mary and the saints. Tradition was declared coequal to Scripture as a source of spiritual knowledge, and the sole right of the church to interpret the Bible was asserted.

At the same time, the council took steps to reform many of the major abuses within the church that had partly incited the Reformation: decrees were issued requiring episcopal residence and a limitation on the plurality of benefices, and movements were instigated to reform certain monastic orders and to provide for the education of the clergy through the creation of a seminary in every diocese.

Several European monarchs kept their distance from the council's decrees, only partially or never enforcing them. The Council of Trent helped, however, to catalyze a movement within the Catholic clergy and laity for widespread religious renewal.

Trent, River The River Trent, 274 km (170 mi) long, rises in central England, just north of Stoke-on-Trent in northern Staffordshire and flows southeast, then northeast past Nottingham, and north to the Humber estuary, which enters the North Sea near Grimsby. The river is used for barge traffic below Nottingham and for water supply and recreation.

Trent Affair The Trent Affair was a diplomatic crisis between Great Britain and the United States during the U.S. Civil War involving freedom of the seas. It began on Nov. 8, 1861, when Capt. Charles WILKES of the U.S. warship *San Jacinto* forcibly removed Confederate diplomats James M. MASON and John SLIDELL from the British mail steamer *Trent* near Havana and took them to Boston, where they were imprisoned. Although to many Northerners this action seemed a triumph for the Union, it went against both international law and longstanding American claims for the rights of neutral vessels. The British government became incensed and sent 8,000 troops to Canada. For a short time President Abraham Lincoln's administration was unwilling to yield. Once enthusiasm had subsided, however, Secretary of State William H. Seward repudiated the seizure and announced (Dec. 26, 1861) that the prisoners would soon be released.

Trentino-Alto Adige [trayn-tee'-noh-ahl'-toh ah'-dee-jay] Trentino-Alto Adige is an autonomous region of northern Italy bordered by Switzerland to the northwest and Austria to the north. With its capital at Trent (Italian: Trento), the region has an area of 13,618 km^2 (5,258 mi^2) and a population of 884,039 (1989 est.). The Tyrolean Alps in the north and the Dolomites in the east support timber and tourist industries. The region supplies Italy with hydroelectric power and minerals, and fertile river valleys of the south provide grain, fruit, wine, and livestock. Formerly known as Venezia Tridentina, the region was annexed to Austria in 1814 as part of the Tyrol and was ceded to Italy in 1919. Most of the inhabitants of the northern province, with its capital at BOLZANO, speak German, whereas a majority of those in the southern province of Trento speak Italian.

Trenton [tren'-tuhn] Trenton, the capital of New Jersey since 1790 and the seat of Mercer County, lies at the head of navigation on the Delaware River, about 48 km (30 mi) north of Philadelphia. The city's population is 88,675 (1990). A port and transportation hub in the New York–Philadelphia corridor, the city is also a major industrial center. Ceramics, rubber, cables, plastics, textiles, plumbing and bathroom fixtures, linoleum, pumps, and paper products are manufactured there. The state museum and Rider College (1865) are located in Trenton.

In 1679, Mahlon Stacy, an English Quaker, built a log mill and a house on the site of the modern city. In 1721 the settlement was named Trenton for William Trent, a Philadelphia merchant who laid out the town. The city was the scene of a December 1776 battle between George Washington's soldiers and Hessian mercenaries during the American Revolution. In 1784 and again in 1799, Trenton served as the capital of the United States. The construction of the Delaware and Raritan Canal and the arrival of the railroad in the 1830s stimulated the city's growth.

Trenton, Battle of The Battle of Trenton (Dec. 26, 1776) was a crucial early victory for the American forces in the American Revolution. On Christmas night 1776, Gen. George Washington and about 2,500 Continental soldiers crossed the ice-clogged Delaware River from Pennsylvania. Early the next morning they surprised Hessian mercenaries in the British service encamped at Trenton, N.J. American casualties were light, but the Hessian commander was mortally wounded in the ensuing battle, and more than 900 of his men were captured. Washington also came away with badly needed arms and stores. After their earlier defeats in New York, the Trenton victory restored the Americans' flagging morale.

trespass [tres'-pas] Trespass is entry into or use of real or personal property without the consent of the one who possesses (owns or controls) that property. Such illegal entry is punishable even if no loss of property or damage results, if the entry was unintentional or accidental, and whether the trespass took the form of invasion by a human being or by some object (for example, a tree cut down that may have fallen on someone else's land). Unless trespass involves force or intimidation that leads to a breach of the peace (see ASSAULT AND BATTERY), trespass is not considered a criminal matter but a TORT, a civil injury.

Trevelyan, G. M. [truh-vel'-yuhn] The English historian George Macaulay Trevelyan, b. Feb. 16, 1876, d. July 21, 1962, wrote in the liberal tradition, principally on 18th- and 19th-century England. Trevelyan, who stressed the development of literary style, was professor of modern history at Cambridge University (1927–40), master of Trinity College, Cambridge (1940–51), and chancellor of Durham University (1949–57). He wrote many books, including studies of the 2d Earl Grey (1920); his father, the historian Sir George Otto Trevelyan (1932); Garibaldi (1907, 1909, 1911); *A History of England* (1926); and *English Social History* (1942).

Trevi Fountain [tray'-vee] The Trevi Fountain in Rome, an enormous structure about 20 m (66 ft) wide, was erected (1732–62) as an imposing entranceway at the point where water from an ancient aqueduct reaches the city. Designed by Nicola Salvi, this spectacular baroque monument is an imaginative fusion of architecture and sculpture with the natural elements of rocks and gushing water. According to popular tradition, any foreigner who throws a coin into the fountain's vast basin is assured of returning to Rome.

Trevino, Lee [truh-vee'-noh] The highly successful American professional golfer Lee Buck Trevino, b. Dallas, Tex., Dec. 1, 1939, competed in Far Eastern tournaments while serving in the U.S. Marines. He worked as a golf instructor after his discharge and won (1965) the Texas State Open. Trevino has twice won the U.S. Open (1968, 1971), the British Open (1971–72), and the Professional Golfers' Association (PGA) title (1974, 1984). He was also the Canadian Open champion three times (1971, 1977, 1979). Trevino has earned the Vardon Trophy, awarded annually to the PGA player with the best average score per round, five times.

Trevithick, Richard [trev'-i-thik] The English engineer and inventor Richard Trevithick, b. Apr. 13, 1771, d. Apr. 22, 1833, built the first high-pressure steam engine and the first steam-powered carriage to transport passengers. In the 1790s, Trevithick constructed improved versions of existing engines and in 1801 built a steam carriage that transported several passengers for a short distance. In 1804 he constructed the first steam locomotive to travel on tracks, proving that an engine pulling carriages on iron wheels running on smooth rails could provide enough traction to transport 5 wagons, 10 tons of ore, and 70 passengers. Trevithick was also the inventor of a steam threshing machine and the first mechanical rock-boring machine.

trial A trial is a formal legal examination before a COURT of civil or criminal issues between two parties, the plaintiff and the defendant. A civil trial is initiated when the plaintiff files a complaint against the defending party to obtain legal redress. A criminal trial usually begins with service of a WARRANT of arrest by the state (plaintiff) on a suspected criminal (defendant) and INDICTMENT of the latter by a GRAND JURY. Article III, Section 2, and the 6th Amendment of the U.S. Constitution require the federal government to grant a JURY trial in criminal cases. The 6th Amendment also guarantees, among other things, the right to a "speedy and public trial," an "impartial jury," and the "assistance of counsel." A federal jury must be composed of 12 persons, and its verdict must be unanimous. A judge, the presiding officer of the trial court, generally rules on matters of LEGAL PROCEDURE and sentencing. The 7th Amendment requires the federal government to guarantee a jury trial in certain kinds of civil cases, but a jury trial often is waived by the parties when small sums of money are involved.

Although state laws on judicial procedure may vary, in 1968 the U.S. Supreme Court applied the 6th Amendment guarantee of a jury trial in criminal cases to the states through the 14TH AMENDMENT. The Court has permitted variations in the number of persons that make up a state jury and has permitted nonunanimous verdicts for some types of criminal offenses.

See also: CIVIL LAW; COMMON LAW; CRIMINAL JUSTICE; DUE PROCESS; EQUITY (law); EVIDENCE; WITNESS.

trial by combat Trial by combat, of which dueling is a form, was revived (501) by Gundobad, king of Burgundy, as a "dint of sword" solution to justice and became in Europe an acceptable legal practice that for centuries was served by special ceremonies and codes of honor. Victory or defeat in the contest signified the "judgment of God" as to a participant's innocence or guilt. Introduced into England by William the Conqueror in the late 11th century, trial by combat, or "Trial by Battel," continued as a legal alternative to trial by jury until 1819. Judicial duels were at first fought only in person by the contestants, but later proxy fighters were allowed to wage battle. Such champions received minor punishment if they lost (and were not killed), but the principals who sponsored them were hanged.

triangle (mathematics) A triangle is a plane geometrical figure formed by three line segments connecting three points not lying on the same line (see POLYGON). Each line segment is called a side, and the points they connect are called vertices. The altitude of a triangle is the perpendicular distance from any vertex to the opposite side, this side then being designated as the base. The area of a triangle is one-half the product of the base and the corresponding altitude. The angles inside the triangle total 180° and are called interior angles.

Variations in interior angles and in relative lengths of the sides permit six different triangles to be distinguished. An acute triangle is one whose interior angles are each less than 90°, whereas an obtuse triangle has one interior angle that is greater than 90° but (by definition) less than 180°. A right triangle contains one interior angle that is equal to 90°, the side opposite this right angle being called the hypotenuse and the other two sides the legs (see PYTHAGORAS, THEOREM OF). A scalene triangle has three unequal sides, an isosceles triangle has two equal sides, and an equilateral triangle has three equal sides.

Special lines can be drawn in a triangle. A line joining a vertex to the middle point of the opposite side is called a median; the three medians of a triangle intersect in one point, called the centroid. A line through a vertex that divides the interior angle into two equal angles is a bisector; the three bisectors intersect in one point, which is the center of a circle inscribed within the triangle—that is, the three sides of the triangle are tangent to the inscribed circle.

triangle (music) The percussion instrument called the triangle is made from a steel rod bent into a triangle with one corner open. It is suspended from a cord and struck with a metal rod. The triangle first entered European music as part of the "Turkish" music that intrigued 18th-century composers and audiences. The instrument is relatively small, each side being about 18 cm (7 in) to 25 cm (10 in) long.

Triassic Period see EARTH, GEOLOGICAL HISTORY OF; GEOLOGIC TIME

tribe In anthropology, the term *tribe* has been used to indicate a group of people sharing common values, general customs, language, and usually contiguous territory. The term commonly refers to groups within which kin relations are important, but it can be extended to groups numbering several million people. The importance of KINSHIP is reflected in the tradition—common in tribal societies—that every member is descended from a real or supposed common ancestor. Tribes may be genetically heterogeneous, however, because of absorption of people of other cultural or genetic backgrounds through adoption, marriage, conquest, or political alliance. The term *tribe* is falling out of favor because it has connotations of backwardness, because areas covered by individual features used as criteria may not coincide with each other or with the political boundaries associated with a tribe, and because large tribes are internally differentiated into distinct groups. In current usage, the terms *ethnic group* and *ethnicity* are commonly preferred to the terms *tribe* and *tribalism*.

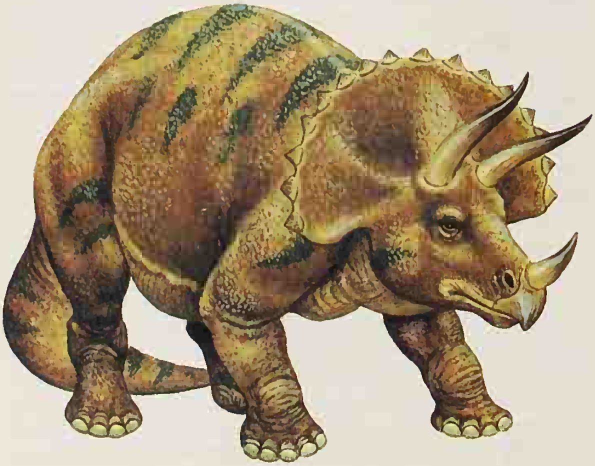
tribunes Tribunes were officials in ancient Rome. Of the various kinds of military and civil tribunates, the most important was the tribune of the plebs. From the early 5th century BC, these tribunes were elected annually by plebeian assemblies; by 449, they numbered 10. Protectors of the PLEBEIANS, the tribunes acquired over the next 200 years the right to veto the actions of the magistrates and to initiate legislation. In the 2d century BC, the GRACCHUS family used the office to pursue radical social ends. Lucius Cornelius SULLA repressed the tribunate in the following century, but it was restored after his death. The office's powers were later assumed by the emperor, although the office itself remained in existence into the 5th century AD.

tributyl tin [try-byoot'-uhl] Tributyl tin (TBT) is an organic compound widely used as an additive in paints for ship hulls because it inhibits the growth of barnacles and algae. Commercially introduced in the 1960s for this purpose, TBT is long-lasting and reduces the need for ship maintenance. It also lowers fuel costs by decreasing the drag caused by hull growths. The use of TBT has come under increasing attack since the 1970s, however, when its toxic and mutation-causing effects on indigenous life forms and commercially grown oysters began to be observed in coastal waters. A paint from which TBT leaches less readily has been developed, but U.S. environmental groups still urge that the use of TBT be severely restricted, as it has been in France (1982) and Great Britain (1986).

Triceratops [try-sair'-uh-tahps] *Triceratops* was one of the last of the highly successful horned dinosaurs (suborder Ceratopsia, order Ornithischia). It is known from perhaps hundreds of partial to complete fossil skeletons collected in western North America from Late Cretaceous rocks about 70 million years old. The name *Triceratops* means "three-horn face."

Triceratops averaged less than 6 m (20 ft) long but attained a length of 9 m (30 ft) and a weight of 6.4 metric tons (7 U.S. tons). A bony shield, or frill, extended back over the neck and shoulders. Even without this frill the head was huge; with the frill included, the skull was more than half as long as the body. This frill, formed by the rearward flaring of the parietal and squamosal bones of the skull, was the distinctive feature of all horned dinosaurs and may have protected the vulnerable neck region against attack. It also provided for the attachment of large neck muscles required for turning and maneuvering the horn-bearing head during combat and provided enlarged areas for attachment of powerful jaw muscles. *Triceratops* possessed a strong, turtlelike beak for plucking plants and long tooth rows in the cheeks for slicing that food—an unusual system among herbivores.

Triceratops, *a herbivorous ceratopsid dinosaur of the Late Cretaceous Period, was about 6 m (20 ft) long and probably weighed about 7 tons. Ceratopsids were the last group of dinosaurs to become extinct.*



trichinosis [trik-uh-noh'-sis] Trichinosis (or trichiniasis), a parasitic disease caused by the roundworm *Trichinella spiralis*, usually results from eating infected pork products that are raw or undercooked. Adult worms live in the lining of the small intestines of pigs, leaving encysted larvae (trichinae) in the intestinal wall. When ingested by humans, the larvae encyst in the stomach, burrow into the intestinal wall, and mature and mate. One adult female worm can produce 1,000 living larvae in 6 weeks. Larvae are carried by the bloodstream to all parts of the body, but the only survivors are those reaching skeletal muscle, particularly the tongue, diaphragm, and pectoral and eye muscles. They invade individual fibers, coil up, and encyst. Encysted larvae may survive for up to 30 years. Gastrointestinal symptoms develop within 1 to 2 days after pork ingestion; fever, nausea, muscular soreness, edema, and eosinophilia occur in 1 to 2 weeks. Symptoms subside in 3 months, after encystment. Trichinosis is prevented through proper cooking and by not feeding hogs infected pork wastes.

Trichomonas [trik-uh-mahn'-uhs] *Trichomonas* is a genus of zooflagellate protozoans in the order Trichomonadida that are common parasites in the digestive system of animals. The cells are pear-shaped and have three to five flagella. Three species are found in humans. *T. vaginalis* can cause trichomoniasis, a genitourinary infection usually transmitted by sexual intercourse. *T. buccalisa*, found in the mouth, and *T. hominis*, found in the intestine, are not pathogenic forms.

triclinic system [try-klin'-ik] CRYSTALS that can be referred to three mutually oblique axes of unequal lengths are classified in the triclinic system. This is the system of lowest symmetry, and it contains only two classes. The first class possesses one center of symmetry, and the second class has no symmetry at all. Triclinic crystals can generally be identified by a lack of any twofold symmetry element and by the oblique axial inclination. Triclinic minerals are in all cases optically biaxial. None of the three optical directions coincide with the three crystallographic directions, and extinction is always inclined. Minerals crystallizing in this system include microline (see FELDSPAR), TURQUOISE, and the plagioclase feldspars.

Trident [try'-dent] Trident 1 (C-4) is a submarine-launched ballistic missile (SLBM) developed for the U.S.

Navy Fleet Ballistic Missile Force (see ROCKETS AND MISSILES). It has three stages; is 10.4 m (34 ft) long, 188 cm (74 in) in diameter, and weighs 29,500 kg (65,047 lb) at lift-off; uses solid fuel; and has a range of about 7,400 km (4,600 mi), approximately 70 percent greater than that of the navy's POSEIDON missile. The Trident's guidance system is lighter than the Poseidon's all-inertial system, and its ability to sight on stars enables the Trident to meet the earlier missile's accuracy objectives at greater ranges. The postboost control system permits corrections for errors in launch-position data while ensuring a high level of terminal maneuverability. Trident's nuclear payload is a multiple independently targeted reentry vehicle, or MIRV (see MIRV MISSILE), that carries eight nuclear warheads of 100-kiloton yield each. By 1987, 8 Ohio-class Trident submarines and 12 refitted Lafayette-class Poseidon submarines each carried 16 Trident missiles. The Trident 2 (D-5) carries a heavier payload; it achieved operational status in 1990.

Trier [treer] Trier (French: Trèves), a city in Rhineland-Palatinate state in southwestern Germany, lies on the Moselle (Mosel) River just east of Luxembourg and 110 km (70 mi) southwest of Bonn. With a population of 93,076 (1987 est.), the city is an important railroad junction and serves as a center for the Moselle wine region. Manufactures include machinery, textiles, beer, and metal and tobacco products. Trier has a theological seminary (1773) and a university (1970). Among its historical sites are the house where Karl Marx was born and many Roman ruins.

Founded by the Roman emperor Augustus in 15 BC as Augusta Treverorum, Trier became capital of the Roman province of Belgica in the 2d century AD and served as an imperial capital and residence from about 295. Trier later became the seat of a bishopric (4th century), archbishopric (9th century), and imperial electorate (12th century). The city was secularized in 1797 and its university (founded 1473) closed. Ceded in turn to France (1801) and Prussia (1815), and occupied by the French after World War I, Trier suffered heavy damage during World War II.

Trieste [tree-es'-tay] Trieste (German: Triest; Slovenian: Trst), a city in northeastern Italy and capital of the Friuli-Venezia Giulia region, lies along the Gulf of Trieste at the head of the Adriatic Sea about 110 km (70 mi) northeast of Venice. Situated on the northwestern side of Istria on the Yugoslav border, Trieste has a population of 235,000 (1988).

Shipbuilding and cargo handling are Trieste's key industries. The city has also become a major international scientific center. Historic sites include Roman ruins, the Romanesque Cathedral of San Giusto (built in the 14th century from two older churches), a medieval castle (1470–1680) housing a museum, and Miramare Castle (1854–56), built for Archduke Maximilian of Austria (later emperor of Mexico). The University of Trieste was founded in 1938.

The ancient city, called Tergeste, fell *c.*177 BC to the Romans; harbor facilities were constructed (33 BC) under the supervision of Emperor Augustus. The Ostrogoths ruled Trieste from AD 493 to 539, followed by the Byzantines (539–752), the Lombards (752–*c.*790), the bishops of Trieste—first as barons (*c.*850–933), then as imperial princes (948–1202)—and finally by Austria for most of the period from 1382 to 1918. Trieste served as an imperial free port from 1719 to 1891, and on the eve of World War I was the Austro-Hungarian empire's principal harbor. Italy occupied the city in 1918 and acquired it formally a year later by the Treaty of Saint Germain. Trieste fell to the Germans in 1943 and to the Yugoslavs in 1945. From 1947 to 1954 the city and its environs were administered as the Free Territory of Trieste, divided into two zones under Yugoslav and U.S.-British control. In 1954 the city and a small part of the territory went to Italy, the rest to Yugoslavia.

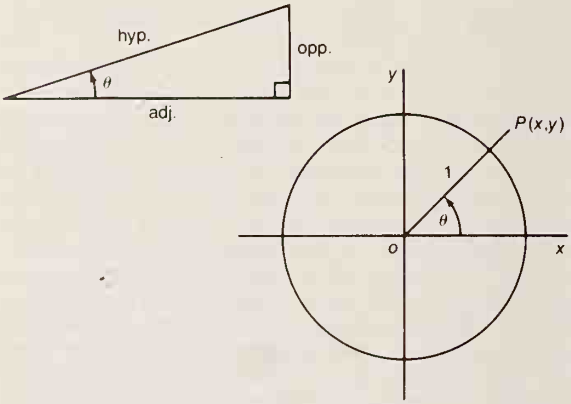
triforium see GOTHIC ART AND ARCHITECTURE; ROMANESQUE ART AND ARCHITECTURE

triggerfish Triggerfish are shallow-water fishes found in oceans around the world but are most common in tropical seas. They are named for the unusual triggering or locking mechanism of their spinous top fin. When the first large spine is erected, the second small spine moves forward, locking the first into an upright position and becoming itself erect. The third spine, if present, then also erects and locks the second spine into an upright position. The locking mechanism can be released only by depressing spines in reverse order: depressing the third spine releases the second from the upright position; depressing the second releases the first. When frightened, a triggerfish dashes into a crevice or hole in a coral reef, erects its top fin, and presses down the lower part of its body. It thus wedges itself tightly into the space and becomes difficult to dislodge. Triggerfish are less than 60 cm (2 ft) long and have variously colored bony scales. They have small mouths with strong teeth and can rotate each eye independently. About 30 species make up the family Balistidae.

trigonometry Trigonometry is a branch of mathematics that developed from simple mensuration (measurement of geometric quantities), GEOMETRY, and SURVEYING. In its modern form it makes use of concepts from algebra and analysis. Initially it involved the mathematics of practical problems, such as construction and land measurement; it has since been extended to the geometry of three-dimensional spaces in the form of SPHERICAL TRIGONOMETRY. Land survey makes use of the process of triangulation, in which a chosen network of triangles is measured. This article, however, will deal only with plane trigonometry.

Basic Concepts. Trigonometric concepts are used to minimize the amount of measuring involved. These concepts depend on the concepts of enlargement and similarity. Equiangular triangles have the same shape, but only in the special case of congruency do they have the same size. Any set of similar triangles has the invariant property of proportionality; that is, ratios of pairs of corresponding sides are in the same proportion. In the language of transformation geometry, for similar triangles, one triangle is an enlargement of another, or any triangle can be transformed into another by applying the same scale factor to each part of the triangle.

Ratios. Trigonometry uses the fact that ratios of pairs of sides of triangles are functions of the angles. The basis for mensuration of triangles is the right-angled triangle. The term *trigonometry* means literally the measurement of trigons (triangles). This mensuration approach defines the six trigonometric ratios in terms of ratios of lengths of sides of a right triangle. The analytic approach defines the ratios in terms of the coordinates of a point on the circumference of a unit circle, $x^2 + y^2 = 1$. These ratios define the trigonometric functions.



If θ is an acute angle, the trigonometric ratios of θ are conveniently defined as ratios of different lengths of the corresponding right triangle: the hypotenuse, the side adjacent to the angle θ, and the side opposite to θ.

sine (sin) θ = opp/hyp
tangent (tan) θ =opp/adj
secant (sec) θ = hyp/adj
cosine (cos) θ = adj/hyp
cotangent (cot, ctn) θ = adj/opp
cosecant (cosec, csc) θ = hyp/opp

Trigonometric Functions. Trigonometric functions, often known as the circular functions, are defined in terms of the trigonometric ratios. If point P (x,y) lies on the circumference of a unit circle $x^2 + y^2 = 1$, then the trigonometric functions of θ, where θ is the angle that the line OP makes with the positive direction of the x-axis, are defined as:

$\sin \theta = y$	$\sec \theta = 1/x$	$\cot \theta = x/y$
$\tan \theta = y/x$	$\cos \theta = x$	$\csc \theta = 1/y$

The signs of the coordinates determine the signs of the ratios. If θ is acute, all ratios are positive; these values of θ are fully tabulated in standard trigonometric tables. The ratios of angles greater than a right angle (90°) can be converted to ratios of acute angles by appropriate reduction formulas.

If $y = \sin x$, then the inverse statement, that x is the angle whose sine is y, is written x = inverse sin y, or arc sin y, or more commonly $\sin^{-1} y$. Hence $x = \sin^{-1} y$ is the inverse function of $y = \sin x$. Similar notation is used for other trigonometric functions. The -1 in the notation is not an exponent, and $\sin^{-1} y$ is different from $(\sin y)^{-1}$; the latter is the reciprocal of $\sin y$.

Trigonometric functions have many applications in algebra, in calculus, and in applied mathematics. They are used in rationalizing quadratic surds (square roots).

Polar Coordinates. Trigonometric functions are used in polar coordinates, the system in which the position of a point P is determined by its distance OP from a fixed point O and by the angle that OP makes with an initial line OX (see COORDINATE SYSTEMS, mathematics).

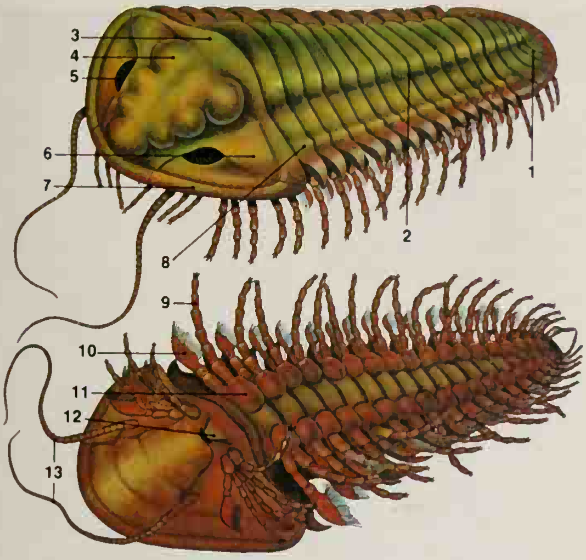
Identity. If a trigonometric equation is true for all values of its variables, it is an identity. Apart from their use in simplifying trigonometric problems, trigonometric identities are often used in algebra and calculus.

trill The trill—often called a shake in British usage—is a musical ornament produced by rapidly alternating a written note with its upper neighbor. It was introduced in the 16th century to enliven cadential patterns, becoming most popular in keyboard and vocal music, although it was adopted generally. By the 17th century, signs and abbreviations (such as t, tr, +, and w) were used to indicate the points at which a trill should be executed.

Trilling, Lionel [tril'-ing] The distinguished critic, teacher, and novelist Lionel Trilling, b. New York City, July 4, 1905, d. Nov. 7, 1975, combined an elegant and passionate response to literature with shrewd analysis of society, politics, and culture. Both qualities are found in his first book, *Matthew Arnold* (1939), and in subsequent collections of essays, the most important being *The Liberal Imagination* (1950). His novel *The Middle of the Journey* (1947) is notable for its play of moral and political ideas; he also wrote such fine short stories as "Of This Time, Of That Place" and "The Other Margaret." Trilling taught English for more than 40 years at Columbia University.

trilobite [try'-luh-byt] Trilobites are extinct marine arthropods whose fossils date from the early Cambrian to the end of the Permian Period, or 600 million to 225 million years ago. They may be closely related to living crustaceans, spiders, and horseshoe crabs.

The trilobite body consisted of few to many segments, most of which bore jointed, branched or unbranched, leglike appendages. The upper body covering, or shell, was typically divided into three longitudinal lobes: a prominent central, or axial, lobe extending from head to tail, and one less prominent, pleural lobe on each side. Most



Trilobites, now extinct, were segmented, hard-shelled marine animals with bodies that consisted of a tailpiece, or pygidium (1), *a thorax* (2), *and a head shield, or cephalon* (3). *The cephalon of a typical* Calymene *trilobite comprised a bulbous glabella* (4), *eyes* (5), *fixed cheeks* (6), *and weakly attached free cheeks* (7). *The thorax contained jointed segments, or pleurons* (8). *The animal had numerous legs for walking* (9), *legs with feathery gills for breathing and swimming* (10), *masticating organs* (11) *that picked up food and passed it to the mouth* (12), *and two antennae with taste and smell organs* (13).

trilobites were also differentiated into three transverse sections: the head, or cephalon, commonly bore eyes and antennae, and it consisted of fused segments more or less formed into a rigid shield; the middle section, or thorax, was flexible, and some trilobites were capable of curling their bodies like modern sow bugs; and the tail, or pygidium, was fused and rigid. The mouth was located at the bottom rear of the head, and the stomach was situated in front of the mouth, in the upper part of the head; the digestive tract, therefore, formed a J-shaped loop inside the head, from the mouth to the stomach. Most trilobites were between 2 and 7 cm (¾ and 2¾ in) long, but sizes could range from 6 mm (¼ in) to almost 75 cm (30 in). The animals molted as they grew.

Trilobites were distributed worldwide in diverse marine environments. Many dug shallow burrows; others probably scurried about on the seafloor, feeding as predators or scavengers. Their fossils are used to make time correlations of rocks and to reconstruct marine environments.

Trincomalee [tring-kuh-muh-lee'] The seaport of Trincomalee lies on a peninsula in Trincomalee Bay on the northeastern coast of Sri Lanka, about 230 km (145 mi) northeast of Colombo. The city's population is 46,000 (1982 est.). The town has good rail and road connections with the rest of the country and one of the world's best natural harbors. Tea is the main export.

Since ancient times the town has been inhabited by Tamil people. The Portuguese arrived in 1622, to be succeeded by the Dutch (1639), French (1673), and British (1795). The British held the port until 1957, even though Sri Lanka became independent in 1948.

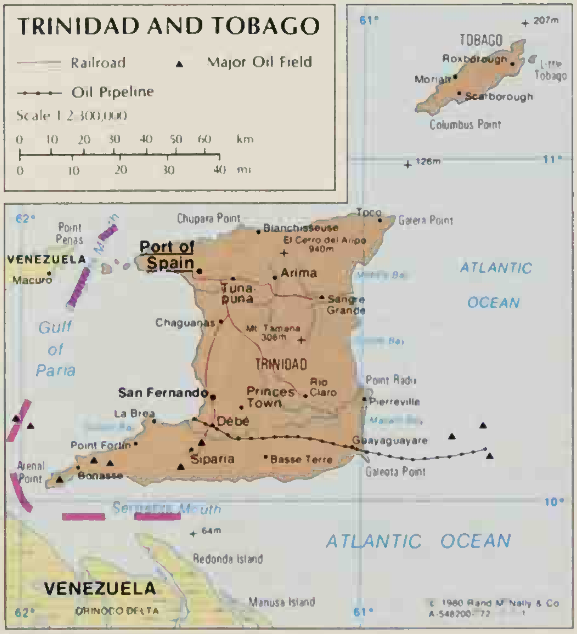
Trinidad and Tobago [trin'-i-dad, tuh-bay'-goh] Trinidad and Tobago is an independent nation in the Caribbean Sea, 11 km (7 mi) from Venezuela. The country, a member of the Commonwealth of Nations, is composed of two islands—Trinidad (4,830 km^2/1,865 mi^2) and Tobago (300 km^2/116 mi^2), which is 31 km (19 mi) to the northeast. The capital and largest city is PORT OF SPAIN.

Land, People, and Economy

Trinidad's main physical feature is the Northern Range, running east to west at an average elevation of 457 m (1,500 ft). It includes the nation's highest point, El Cerro del Aripo (940 m/3,084 ft). The Central and Southern ranges run parallel to, but are not as high as, the Northern Range. Tobago's Main Range follows the island's northeast-southwest trend. The climate is tropical, with a mean annual temperature of 27° C (80° F). Rainfall totals about 1,780 mm (70 in) annually.

The people of Trinidad and Tobago are mostly of African (43%) and Asian Indian (40%) descent. Free secondary education was introduced in 1960. Health services are free.

Petroleum and gas production dominates the Trinidad and Tobago economy, and petroleum and petroleum products accounted for 70% of exports in 1987 despite the worldwide oil glut of the mid-1980s, which has



AT A GLANCE

REPUBLIC OF TRINIDAD AND TOBAGO

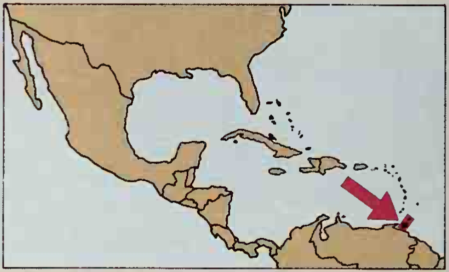
Land: Area: 5,130 km^2 (1,981 mi^2). Capital and largest city: Port of Spain (1987 est. pop., 58,300).

People: Population (1990 est.): 1,233,000. Density: 240 persons per km^2 (622 per mi^2). Distribution (1990): 64% urban, 36% rural. Official language: English. Major religions: Roman Catholicism, Hinduism, Protestantism, Islam.

Government: Type: republic. Legislature: House of Representatives, Senate. Political subdivisions: 8 counties, 3 municipalities..

Economy: GNP (1989): $4 billion; $3,160 per capita. Labor distribution (1988): agriculture, forestry, hunting, and fishing—11%; mining, quarrying, and manufacturing—15%; construction—17%; transport and communications—7%; trade—16%; services and other—34%. Foreign trade (1988): imports—$1.1 billion; exports—$1.4 billion. Currency: 1 Trinidad and Tobago dollar = 100 cents.

Education and Health: Literacy (1990): 98% of adult population. Universities (1990): 1. Hospital beds (1988): 4,599. Physicians (1988): 1,025. Life expectancy (1990): women—74; men—69. Infant mortality (1990): 10 per 1,000 live births.



caused economic decline. Pitch Lake on Trinidad is the world's largest natural source of asphalt. Major industries in addition to petrochemical production include food processing and cement production. Tourists—attracted by the beaches and the annual carnival, featuring calypso and steel band music—are an important source of revenue. Although agricultural production is economically important—sugar, cocoa, coffee, and citrus are exported—the nation is largely dependent on food imports.

History and Government

Trinidad, discovered by Christopher Columbus in 1498, was first a Spanish and then (1797) a British colony. The first British settlers (1616) on Tobago were driven out by the Carib Indians. The island then came under Dutch and French control before the British acquired it in 1814. Trinidad and Tobago were politically united in 1888 and in 1962 became independent. Tobago was given internal self-government in 1987. In July 1990 a black Islamic group staged an unsuccessful coup against the government.

Trinity The Trinity refers to the Christian understanding of God as a unity of three persons: Father, Son, and Holy Spirit. All are equally God and so are one, each sharing in the divine attributes of ultimacy, eternity, and changelessness; yet they are distinguishable in their relations to each other and in their roles within creaturely and human life and destiny.

The doctrine of the Trinity is a postscriptural attempt to bring to coherent expression diverse affirmations about God, all of which seemed necessary to a full statement of Christian experience and belief. First, from the Hebrew Scriptures and the clear tradition of Jesus' teaching, the church affirmed that not only is God one, but is also the creative and sovereign Father and thus, by implication, transcendent of finite limits, time, and change—all of which characterize God's creatures. Second, it was affirmed that Jesus Christ was more than a great prophet adopted by God; rather, he was "the Son of God," "the Word made flesh," the divine logos itself incarnate in a man. Third, the Holy Spirit, from whose presence the community of believers received their faith, their confidence in the truth of that faith, their holiness, and, above all, the efficacy of both baptism and the Eucharist, was necessarily also God—God's presence in their midst. For Christians, then, the one God appeared in what they called a threefold "economy," in, so to speak, three forms or modes.

Difficulties soon emerged in formulating and understanding this threefold "economy." Divergent views led early to numerous Trinitarian controversies such as those over subordinationism (the teaching that the Son is subordinate to the Father, and the Holy Spirit to both; see Arianism) and modalism (the view that the three modes are transitory; see Sabellianism). The Councils of Nicaea (325) and Constantinople (381) outlined the dogma of the Trinity in express rejection of these teachings. In the 20th century, the theologians Karl Barth, Paul Tillich, and Karl Rahner, despite their diversity of outlook, have again found the Trinity a central, in fact an unavoidable, structure for expressing the Christian understanding of God.

triode [try'-ohd] A triode is a three-terminal ELECTRON TUBE that can control the flow of current between its cathode and its anode by means of a voltage applied to a third element, the grid. The triode is used to amplify weak alternating current (AC) signals (see AMPLIFIER). If the tube is gas-filled, it is known as a thyratron, which is essentially a controlled RECTIFIER rather than an amplifier. A triode can also be used in an OSCILLATOR circuit. The triode, initially known as the audion, evolved from the DIODE when in 1907 the American inventor Lee DE FOREST added the grid between the cathode and the anode.

The triode is a thermionic device. That is, heat is required to make the cathode emit electrons (see THERMIONIC EMISSION). The grid between the cathode and the plate is maintained at some average negative voltage (bias), which tends to repel some electrons and reduces the current. If a small AC signal voltage, however, is applied to the grid, superimposed on the DC voltage, the electrons flowing through the tube will alternately increase and decrease from the previous average level. This variation in current flowing through a resistor in the external anode circuit develops the amplified output signal.

Triodes have been almost completely replaced by the generally smaller, cooler, and more reliable TRANSISTOR in most audio, radio, television, and computer applications, although many remain in existing equipment. A few applications exist at high frequencies (the low end of the microwave region), where large amounts of power are required, particularly in communications equipment.

Triple Alliance The name *Triple Alliance* has been applied to several separate coalitions of European powers. The Triple Alliance of 1668, formed by England, Sweden, and the Dutch Republic, was aimed at halting encroachment into the Low Countries by France. The Triple Alliance of 1717, made up of France, Britain, and the Dutch Republic, was directed against Spanish aspirations to Italian territory. The Holy Roman emperor's adherence to the pact in 1718 made it a Quadruple Alliance. The Triple Alliance of 1788, consisting of Britain, the Dutch Republic, and Prussia, sought to check French influence in the Netherlands and Russia's ambitions in the Middle East.

The most famous Triple Alliance was that of 1882, composed of Germany, Austria-Hungary, and Italy. Its terms provided that if any of the parties were attacked by two or more powers, its allies would come to its aid. Orchestrated by German chancellor Otto von BISMARCK, it originated with the Dual Alliance of 1879, between Germany and Austria-Hungary, to which Italy was added in 1882. Germany was motivated by a desire to isolate France; Austria-Hungary sought support against Russia, its rival in the Balkans; and Italy, although fearful of Austro-Hungarian expansion, wanted help in pursuing its North African territorial ambitions.

Meanwhile, a series of bilateral agreements produced the TRIPLE ENTENTE (1907) among Britain, France, and Russia. Europe was thus divided into the two camps that fought each other in WORLD WAR I, except that Italy renounced the alliance and joined the Entente powers in 1915.

Triple Alliance, War of the In the War of the Triple Alliance (1865–70), also known as the Paraguayan War, Paraguay confronted an alliance of Argentina, Brazil, and Uruguay. Hostilities began when Uruguayan conservatives convinced the dictator of Paraguay, Francisco Solano LÓPEZ, that Brazil and Argentina were about to invade Paraguay. López declared war (January 1865) on Brazil and then on Argentina when Argentine president Bartolomé Mitre refused him permission to cross Argentine territory. Uruguay, which had made a secret alliance with Brazil and Argentina, declared war on May 1, 1865. Alliance armies defeated the vastly outnumbered Paraguayan forces and then blockaded all river traffic, but the Paraguayans fought back, subduing the alliance at Curupayty (September 1866). In 1868, Brazilian troops took river fortresses, and at the beginning of 1869, alliance forces sacked the Paraguayan capital at Asunción. The bloody war ended the following year. Paraguay, whose population was severely reduced, took decades to recover.

Triple Entente The Triple Entente—an alignment of Britain, France, and Russia that led to their alliance in WORLD WAR I—resulted from a series of bilateral agreements among them between 1894 and 1907. The Franco-Russian Alliance of 1894 stemmed from France's fear of isolation at the hands of Germany, which had formed the TRIPLE ALLIANCE with Austria-Hungary and Italy in 1882. Russia wanted support against Austria-Hungary, its rival in the Balkans. In 1904, Britain, fearing growing German naval power, entered into the Entente Cordiale with France. Thus, the two longtime antagonists terminated their colonial rivalry in Africa. Britain also sought reconciliation with Russia, which was amenable following a humiliating defeat in the Russo-Japanese War (1904–05). The Anglo-Russian Convention of 1907 settled their differences by establishing separate spheres of influence in Persia. With this agreement, the Triple Entente, an understanding rather than an alliance, was complete. In World War I the Triple Entente faced the Triple Alliance minus Italy, which defected to the Entente.

triple point see PHASE EQUILIBRIUM

Tripoli (Lebanon) [trip'-uh-lee] Tripoli (Arabic: Tarabulus) is a city in northwestern Lebanon located north of Beirut on the Mediterranean Sea. Lebanon's second largest city, it is a major commercial port with a population of 198,000 (1982 est.). The inhabitants are mainly Muslims. Petroleum refining, sponge fishing, fruit and tobacco processing, and citrus-fruit exporting dominate the economy. Of historical interest are the Great Mosque (1294), the Teynal Mosque (1336), and the 15th-century Tower of the Lions, which protected the port.

Founded in the 7th century BC, Tripoli was in 300 BC the capital of Tripolis, a Phoenician federation including Sidon, Tyre, and Aradus. Tripoli was ruled by the Seleucids (198–64 BC), Romans and Byzantines (64 BC–AD 638), and Arabs (from AD 638). The city and its famous library were destroyed in the early 12th century during the First Crusade. Crusaders rebuilt the city and made it a bishopric, but it was destroyed in 1289 by Mamelukes, who ruled until 1516. Tripoli became part of Lebanon in 1920.

Tripoli (Libya) Tripoli, the capital of Libya, is located in the northwestern part of the country on the Mediterranean Sea. Its population is 591,100 (1988 est.). Tripoli is Libya's main port and has major road and air connections. The city lies in an oasis and receives the products (olives, citrus fruits, and tobacco) of the surrounding agricultural region. Industries include fishing, carpet weaving, tanning, and shipping. Among the landmarks are the marble Marcus Aurelius Triumphal Arch (AD 163), the Karamanli Mosque (1736), and the Mosque of Gurgi (1883).

Tripoli (known in ancient times as Oea) was founded by the Phoenicians in the 7th century BC. It was later taken by the Romans (146 BC), the Vandals (AD *c.*450), the Byzantines (6th century), and the Arabs (7th century). Apart from a brief period of Norman rule (1146–58), Tripoli remained under Arab control until 1510, when it fell to the Spanish. Conquered by the Turks in 1551, it became a provincial capital of the Ottoman Empire and a major center of the Barbary pirates (see BARBARY STATES). Italy seized Tripoli in the Italo-Libyan War of 1911–12. The British held the city from 1943 until Libya's independence in 1951. In 1986, after U.S. air attacks on Libya in retaliation for its support of international terrorism, government agencies were moved out of the city to remote villages.

Tripolitan War [trih-pahl'-i-tuhn] The Tripolitan War (1801–05) between the United States and Tripoli was an effort by the United States to end extortion payments to Barbary Coast pirates.

Prior to 1801 the United States, along with the European powers, routinely negotiated extortionate treaties and paid tribute to the North African BARBARY STATES (Tripoli, Algiers, Morocco, and Tunis) in exchange for the safe passage of merchant vessels through the Mediterranean. In 1801 the pasha of Tripoli repudiated his treaty with the United States and declared war. President Thomas Jefferson dispatched the navy's Mediterranean squadron. Between 1803 and 1805, Commodore Edward PREBLE bombarded and blockaded Tripoli, Lieutenant Stephen DECATUR entered Tripoli harbor and burned the captured frigate *Philadelphia*, and William Eaton launched an overland campaign. In 1805 the pasha signed a treaty requiring ransom for American prisoners plus occasional presents but ending annual tribute.

A final resolution of the problems with the Barbary States came in 1815 when Congress declared war on Algiers. Decatur rushed a squadron to the Mediterranean, where he dictated peace on American terms to Algiers and then to Tunis and Tripoli. The American payment of tribute and the intermittent wars with the Barbary States ended, but the United States established a permanent naval squadron in the Mediterranean.

trireme see GALLEY

Tristan and Isolde [tris'-tuhn, i-sohl'-duh] Tristan and Isolde, or Tristram and Iseult, are famous lovers in Celtic and Arthurian legend (see ARTHUR AND ARTHURIAN LEGEND). Tristan, nephew of King Mark of Cornwall, and Isolde, Mark's wife, drink a love potion and become tragically enmeshed in an adulterous passion that involves them in secrecy and intrigue. Their story was told in the Middle Ages by the Anglo-Norman poet Thomas (*c.*1170), by GOTTFRIED VON STRASSBURG, who inspired Richard Wagner's opera, and by Sir Thomas MALORY, in his *Morte Darthur*; and in the 19th century by Tennyson (in *Idylls of the King*, 1859–85), Matthew Arnold ("Tristram and Iseult," 1852), and Swinburne (*Tristram of Lyonesse*, 1882).

Tristan da Cunha Islands [tris'-tan duh koo'-nuh] The Tristan da Cunha Islands are a group of small volcanic islands in the south Atlantic Ocean. The islands are a dependency of the British colony of Saint Helena. The largest and northernmost island, also called Tristan da Cunha, is the only one that is inhabited. The total area is about 117 km^2 (45 mi^2); Tristan da Cunha island has an area of 104 km^2 (40 mi^2). A volcano 2,060 m (6,760 ft) high is in the center of the island. The population of 306 (1988) speaks a 19th-century English dialect. Edinburgh is the island's main village. Fishing is the principal occupation. A weather station operates on Gough, and a radio base is located on Tristan.

The islands were discovered in 1506 by the Portuguese Tristão da CUNHA. The first inhabitants, originally from Saint Helena, were shipwrecked on Tristan during the 19th century. The British took formal control in 1816. Tristan's volcano erupted in 1961, and the inhabitants were evacuated to England. Most of them returned to the island by 1963.

Tristram Shandy [tris'-truhm shan'-dee] *The Life and Opinions of Tristram Shandy, Gentleman* (1759–67), by Laurence STERNE, is ostensibly an autobiography, with the narrator beginning with the circumstances of his conception. Actually, it consists mostly of character sketches and anecdotes in which Tristram describes his family and friends, notably his father, Walter, his uncle Toby, and Parson Yorick. The result is a parody of the order and coherence of novels. Sterne was influenced by satirists such as Rabelais and Swift, but the book is based on John

Locke's theory of the association of ideas, and much of its comedy comes from the special associations that define each character.

tritium [trit'-ee-uhm] Tritium, ^3H or T, is the heaviest hydrogen isotope and the only radioactive form of HYDROGEN. Its nucleus contains 2 neutrons and 1 proton, and its atomic weight is 3.016. Tritium has a half-life of 12.26 years. Before 1954 rainwater contained between 1 and 10 tritium atoms to every 10^{18} hydrogen atoms, but because tritium is used in nuclear weapons, thermonuclear tests sharply raised this proportion. Tritium is also used in the luminous dials of watches and other permanent light sources. In biological research it is used as an isotopic tracer (see NUCLEAR MEDICINE), especially in DNA and RNA studies.

Triton (astronomy) [tryt'-uhn] Triton, the largest satellite of the planet NEPTUNE, was discovered in 1848 by the British astronomer William Lassell. It was first observed at close range by the U.S. spacecraft *Voyager 2* in August 1989. With a diameter of 2,705 km (1,691 mi), it is slightly smaller than Earth's Moon. Unlike any other of the solar system's large satellites, it travels in a retrograde direction—opposite to Neptune's direction of rotation. It has an atmosphere and is the only object in the solar system besides Earth and Io known to have active surface features.

Triton's surface is remarkably diverse. Some areas are smooth and crater free, suggesting a young surface by solar-system standards. Grooves and ridges cut across the icy landscape, which is extremely cold—about –236° C (–393° F). Unique types of features include a "cantaloupe" terrain with roughly circular depressions having upraised rims. The depressions are probably not impact craters, being too similar in size and too regularly spaced. More likely they are associated with local melting and collapse. Other regions are unique in having dark gray markings with sharply defined bright borders. The slightly pinkish south polar cap is highly reflective and may consist of a slowly evaporating layer of nitrogen ice. Northward the surface is generally darker and redder, perhaps through modification of surface methane ice by ultraviolet and magnetospheric radiation.

Triton's atmosphere is composed primarily of nitrogen, with some methane, and may extend as high as 800 km (500 mi). In addition, a thin haze appears to be concentrated about 3 km (2 mi) above the surface but may extend upward to at least 14 km (9 mi).

Triton (mythology) In Greek mythology Triton, a gigantic sea god, part man and part fish, was the son of Amphitrite and POSEIDON. He raised rocks from the sea and created islands with his trident, and he blew on a trumpet made from a conch shell. Triton freed AENEAS's ships when they were grounded in a storm, but when Misenus, Aeneas's main trumpeter, challenged Triton to a musical contest, Triton drowned him.

triumvirate [try-uhm'-vur-uht] The triumvirates of ancient Rome, boards made up of three men, were used in various kinds of administration. In one famous triumvirate, sometimes called the First Triumvirate (60–53 BC), Julius CAESAR, Marcus Licinius CRASSUS, and POMPEY THE GREAT joined together unofficially to rule Rome and its dominions. The so-called Second Triumvirate, an official arrangement created in 43 BC to establish order following Caesar's assassination, consisted of Mark ANTONY, Octavian (later AUGUSTUS), and Marcus Aemilius LEPIDUS. Octavian eventually became sole ruler.

Trobriand Islanders [troh'-bree-and] The Trobriand Islanders are MELANESIANS who occupy a group of small coral islands north of New Guinea in the Pacific Ocean. They are primarily garden horticulturists, with particular villages specializing in fishing, carving, and woodwork. A traditional Trobriand village consisted of two concentric circles, an outer ring of dwellings and an inner ring of storehouses for yams. The subclan was based on matrilineal descent. On reaching maturity, a male youth joined his mother's brother and other members of that subclan. At the annual harvest, a man gave the larger part of his share to his sister's household. The Trobriand Islanders live at the center of the KULA RING, a highly systematized circular pattern of trade among the island groups east and north of New Guinea. The islanders have long had contact with missionaries and administrators and, more recently, with tourists. Trobriand Islanders numbered about 12,700 in the early 1970s.

Troeltsch, Ernst [trurlch] Ernest Troeltsch, b. Feb. 17, 1865, d. Feb. 1, 1923, a German Protestant theologian, sociologist, and philosopher, made significant contributions to the sociology of religion and the philosophy of history through a lifelong effort to reconcile the absolute claims of theology and ethics with the relative facts of historical and social change.

Two contrasting assumptions governed Troeltsch's inquiries: (1) The laws of morality are, as Immanuel Kant held, universal and necessary, and (2) studies in history and sociology reveal the growth and change of moral consciousness over time and across cultures. These two assumptions can be unified, Troeltsch held, only through the belief that absolute morality must realize itself through persons in history, not in value systems. Kant's ethics are thus fulfilled in an "ontology of personality."

trogon [troh'-gahn] Trogons are small or medium-sized tropical birds with beautifully colored, often iridescent plumage. Some 34 species, including the QUETZAL, make up the family Trogonidae.

Trogons are found in tropical Africa and Asia, the Philippines and Malaysia, and from South America north through Mexico; one species—the elegant, or coppery-tailed, trogon, *Trogon elegans,* a metallic, golden green bird less than 30 cm (1 ft) long—ranges into Texas and Arizona. Trogons typically have a short, broad, and sometimes serrate bill and a long tail. The small feet are unique, with the first and second toes directed backward and the third and fourth directed forward. Trogons feed on insects, other small prey, and fruit.

Trois-Rivières [twah-ree-vee-air'] Trois-Rivières, a port city in Quebec, midway between the cities of Montreal and Quebec, lies on the northern shore of the St. Lawrence River at the mouth of the Saint Maurice River. It has a population of 50,122 (1986). The city's industries produce pulp, textiles, and paper, particularly newsprint. It is the site of an Ursuline convent (1697), the University of Quebec at Trois-Rivières (1969), a museum, and many historic buildings, including the ruins of Les Forges Saint Maurice, an iron foundry dating from about 1730.

One of the oldest settlements of Canada, Trois-Rivières was founded in 1634 by Samuel de Champlain and named for the three channels of the Saint Maurice River at this point.

Trojan War [troh'-juhn] In Greek mythology the Trojan War pitted a coalition of Greek principalities against TROY, a city located on the coast of what is now Anatolia, just south of the entrance to the Dardanelles. The war was the subject of HOMER's *Iliad* and *Odyssey*.

According to Homer and other Greek epic poets, King PRIAM's son PARIS brought HELEN, wife of King MENELAUS of Sparta, back to Troy with him. To recover Helen, the Greeks sent an expedition to Troy under AGAMEMNON, brother of Menelaus. The war lasted 10 years, although the first 9 years seem to have been indecisive. Only in the tenth year, after ACHILLES had killed HECTOR, the greatest of the Trojan warriors, were the Greeks assured of victory.

Using a stratagem devised by ODYSSEUS, the Greeks feigned retreat; the Greek fleet sailed out of sight, leaving behind as a "gift" the Trojan Horse. Inside the large wooden horse was concealed a squad of Greek soldiers who, after the horse had been dragged into the unsuspecting city and under the cover of darkness, emerged and opened the gates. After the Greek fleet quietly returned, the soldiers entered Troy and great slaughter followed. Many Trojan women, including members of the royal family, were carried off into captivity.

The work of the 19th-century archaeologist Heinrich SCHLIEMANN showed that the story of the war was probably based on historical events of the early 12th century BC.

trolley car see STREETCAR

Trollope, Anthony [trahl'-uhp] The prolific and popular novelist Anthony Trollope, b. Apr. 24, 1815, d. Dec. 6, 1882, left in his many works a rich record of the manners of clerical and political life in Victorian England. The son of Frances Trollope, who published more than 100 works including *The Domestic Manners of the Americans* (1832), Trollope served as a clerk in the Post Office, ultimately becoming an important official.

Anthony Trollope, portrayed (1865) by Samuel Laurence, was one of the most popular novelists of the Victorian age. Initially famous for his Barsetshire novels, today Trollope is acclaimed also for the Palliser series of novels and for The Way We Live Now *(1875). (National Portrait Gallery, London.)*

His first novel, *MacDermots of Bally Coran* (1845), was unsuccessful, but in 1855 he established his reputation with *The Warden*, the first of the chronicles of Barsetshire, a series of novels dealing with clerical life in the imaginary cathedral city of Barchester. In later works of this group, such as *Barchester Towers* (1857), *Doctor Thorne* (1858), and *The Last Chronicle of Barset* (1867), he concentrated less on religious issues than on personal relationships.

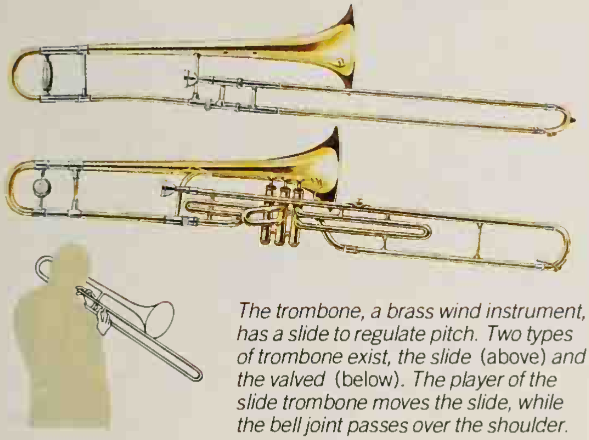
After an unsuccessful campaign for Parliament, Trollope's interest in political life found expression in the series of parliamentary novels that follow the fortunes of the aristocratic Palliser family and the newly rich Phineas Finn. In such novels as *Phineas Finn: The Irish Member* (1869), *The Eustace Diamonds* (1873), and *The Prime Minister* (1876), Trollope is more concerned with the relations between the sexes than with the political conflicts of his day. He also published such social satires as *The Way We Live Now* (1875) and a romance of the future, *The Fixed Period* (1882).

trombone The trombone emerged as a variation of the medieval TRUMPET when the slide, in the form of a U-bend, was created (mid-15th century), immediately producing an efficient and unique low brass instrument capable of playing all chromatics. From that time to the present, the instrument has consisted fundamentally of a bell section including attached inner slides, outer slides, and a mouthpiece, the tube being cylindrical up to a gradual expansion toward the bell.

The early trombone (sackbut) differs from its modern counterpart primarily by its narrow tube of heavier metal, its small expansion at the end, and its funnel-shaped mouthpiece similar to the horn, the result being a mellow tone with command of soft through moderately loud dynamics, eminently suitable for combining with voices, soft woodwinds, or strings. It was soon characterized as a solemn instrument to be used at court, church, and civic functions.

By the end of the 18th century, the trombone had acquired a flared bell and tubular stays. It had also lost popularity temporarily. Its revival was sparked by the need of the developing military bands for a brighter sound with louder dynamics. Makers responded to this demand, thinning the metal, enlarging the bore, and changing the mouthpiece to a hemispherical shape with a sharp edge at the throat. Opera, having used trombones sporadically, now exploited their brilliant tone, and by the mid-19th century German orchestras had adopted three as a standard: the E-flat alto, B-flat tenor, and F bass.

The French, however, used three tenors. Eventually the French usage prevailed, and the alto became obsolete. The third tenor was combined, by means of a left-hand thumb valve, with tubing to extend the horn to the bass range.



The trombone, a brass wind instrument, has a slide to regulate pitch. Two types of trombone exist, the slide (above) *and the valved* (below). *The player of the slide trombone moves the slide, while the bell joint passes over the shoulder.*

trompe l'oeil see ILLUSIONISM

Trondheim [trohn'-haym] Trondheim, a city on the west central coast of Norway, is situated about 400 km (250 mi) north of Oslo. An important transportation hub and seaport, it has a population of 137,408 (1990 est.). Shipbuilding and manufacturing of hardware, building materials, and fish products are the main industries. The Technical University of Norway (1900) is there. Historical landmarks include Nidaros Cathedral (1075), where several Norse kings and Norway's King Haakon VII (r. 1905–57) were crowned; it contains the tomb of St. King Olaf II (Saint Olaf).

Founded as Kaupangr by King Olaf I in 997, Trondheim was an archbishopric from 1152 until the Reformation (1537). The city was an important commercial center during the 12th and 13th centuries, but its importance later diminished.

trope see FIGURES OF SPEECH

tropic bird Tropic birds are seabirds that have the middle tail feathers extremely elongated—up to 53 cm (21 in) long. The three species, which make up the genus *Phaethon*, family Phaethontidae, are found in all warm oceans. Excluding the tail feathers, tropic birds are about 40–48 cm (16–19 in) long and have stout, pointed bills, large, powerful wings, and very short legs with webbed toes. The plumage is white with some black on the head and wings. Clumsy on land, tropic birds are graceful in the air, often making long flights far out to sea. They also occasionally hover over fishing grounds, diving for their prey—mainly fish and squid. A single oval egg is laid on a ledge, typically within a small hole or rock crevice or under vegetation. Both parents incubate the eggs and care for the young.

tropic of Cancer The tropic of Cancer corresponds approximately to the 23°30' north latitude. Considered the boundary between the torrid zone of the tropics and the temperate zone of the middle latitudes, it defines the northern extent of the perpendicular rays of the Sun, which reach it about June 21, to mark the Northern Hemisphere's summer solstice.

tropic of Capricorn The tropic of Capricorn corresponds approximately to 23°30' south latitude. It marks the southern extent of the perpendicular rays of the Sun and the artificial boundary between the tropics and the southern temperate zone. The Northern Hemisphere's winter solstice occurs when the perpendicular rays of the Sun reach the tropic of Capricorn, about December 21.

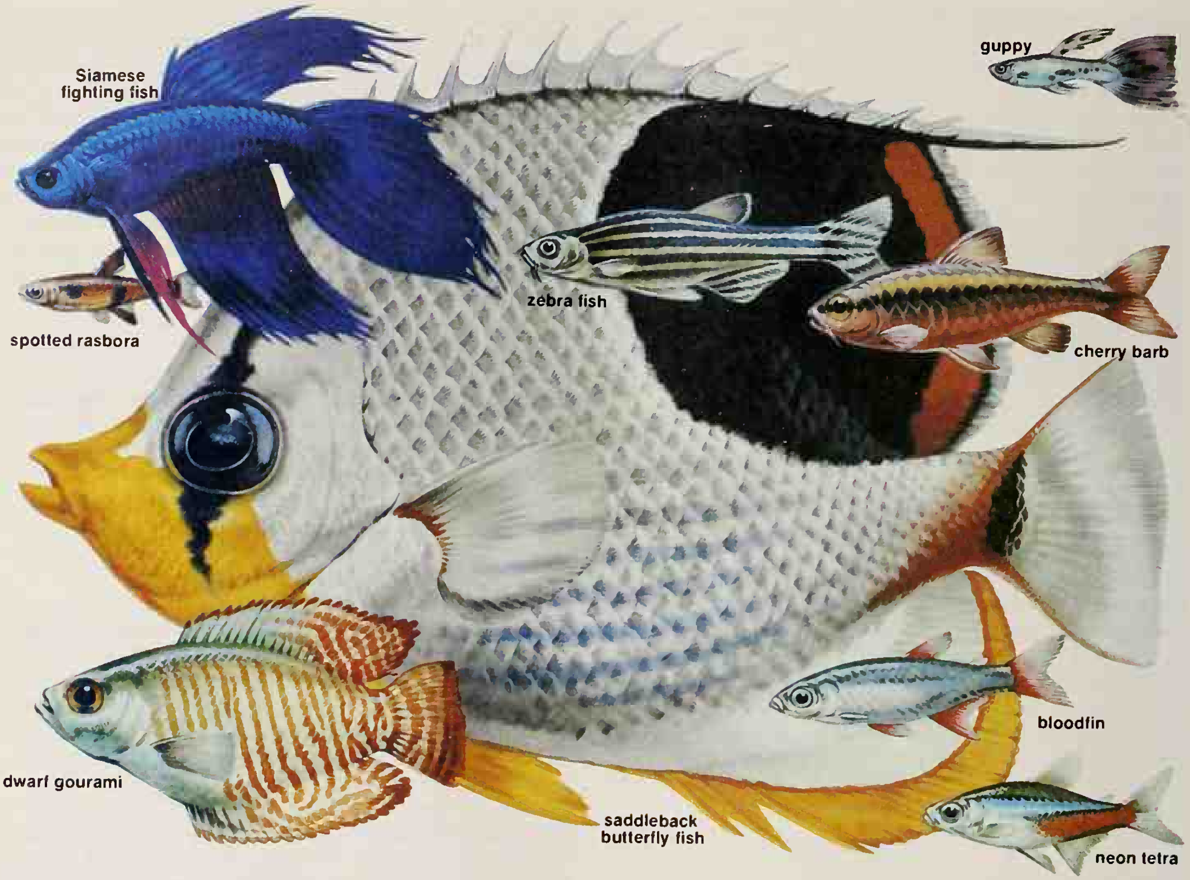
tropical climate The tropics, the region of the Earth between the latitudes 30° north and 30° south, encompasses a wide variety of climate regimes.

The trade-wind belt, which extends across most of the tropical Atlantic and Pacific oceans, is a region characterized by rather steady winds and relatively small seasonal variations in rainfall and temperature. Trade-wind climates vary from very dry conditions in the eastern oceans to very wet conditions in the western oceans.

The equatorial climate regime is characterized by a broad band of low pressure centered near the intertropical convergence zone (ITCZ). Locations close to the equator tend to have two rainy seasons corresponding to the passages of the ITCZ during its northward and southward migration.

The continental tropics have climates characterized by monsoons (from the Arabic *mausin*, a "season"). Monsoon circulations are driven by the seasonally reversing temperature difference between the land surface and the adjacent ocean. In the summer, when the land surface is warmer than the sea surface, the low-level winds are directed from sea to land, whereas in the winter the winds are reversed.

tropical fish Tropical fish are small fishes that have become popular as pets in aquariums because of their beauty and their interesting behavior. Most aquarium



Diversity in coloration and body form have contributed to the popularity of tropical fish. The guppy is a prolific live-bearer. The danio family includes the blue-striped zebra fish and the spotted rasbora. The bloodfin and the neon tetra are named for their striking coloration, as is the cherry barb. A laterally compressed body and long dorsal and anal fins characterize the dwarf gourami. Male Siamese fighting fish have been selectively bred for flamboyant colors. The saddleback butterfly fish is a popular marine aquarium fish.

fishes are in fact from the tropics or warm temperate areas, but the term is also used for some species from cooler waters. Several hundred species of fish, most of them freshwater species, have become adapted to aquarium life. The most popular belong to the families Poeciliidae (the live-bearing GUPPIES and platys), Characidae (the TETRAS), Cyprinidae (the MINNOWS, CARPS, and barbs), Cichlidae (the ANGELFISHES and jewelfishes), and Anabantidae (the labyrinth fishes). In recent years saltwater aquariums have become more popular, and a large number of marine fishes are now raised, many from the family Chaetodontidae.

Raising aquarium fish is believed to be the second most popular hobby in the United States (after photography). In the past most tropical fish were imported, with South America supplying the greatest number. Africa is the place of origin of many cichlids and catfishes, and southern Asia supplies gouramis, danios, and barbs. Today most tropical fish sold in the United States have been raised domestically.

Freshwater Fish. The live-bearers (family Poeciliidae) are among the most fascinating and popular of aquarium fishes. These are all small fishes—SWORDTAILS, guppies, and platys—from the warmer parts of North and South America. Fertilization is internal, and the young are born alive. The anal fin of the male is modified into an elongated gonopodium used to insert the sperm. The young are retained in the oviducts of the female but derive no nourishment from her body.

The guppy, *Poecilia reticulata*, named for the Reverend Robert Guppy, an Anglican clergyman who brought back the first of these from Trinidad in the 19th century, is perhaps the most popular of the tropical fishes. Guppies have been selectively bred to produce a wide variety of colors and characters. The platys, which are small, stockily built fishes from southern Mexico, exhibit brilliant color variants and modified forms. Swordtails from Central America and Mexico are vividly and variously colored.

Tetras and other members of the family Characidae are among the most brilliantly colored of fishes; they are popular also for their graceful movements, small size, and liveliness. The young of characins receive no care from the parents, who may in fact feed on them. The head-and-tail-light fish, *Hemigrammus ocellifer*, has dazzling coppery spots at the top of the eye and the top of the tail. The bloodfin, *Aphyocharax rubripinnis*, has flaming fins that contrast with a silvery to purplish body.

Goldfish (family Cyprinidae) are perhaps the original aquarium fishes and are still very popular. They have been bred for centuries to produce striking colors and astonishing varieties. The danios are brightly colored cyprinids from Southeast Asia. The barbs are small, strikingly attractive fishes from Asia and Africa.

Members of the family Anabantidae are often highly colored, but perhaps their main attraction is their breeding behavior. These fishes have accessory air chambers, and they use oxygen directly from the air as well as through gills; air is also used in nest building. The Siamese fighting fish, *Betta splendens*, is the best known of the anabantids. The paradise fish, *Macropodus opercularis*, and the gouramis, genus *Colisa*, are other popular anabantids.

Saltwater Fish. Saltwater tropical fishes are more difficult to raise than those from freshwater, but recent advances, including the development of artificial seawater and subsand filters, have made it possible for many more people to maintain these fishes. Perhaps the most popular saltwater tropicals are the angelfishes and the butterfly fishes (family Chaetodontidae). Another popular saltwater aquarium fish is the sea horse. It swims upright in a slow and stately manner by the propeller action of its dorsal fin.

tropism [trohp'-izm] In botany the orientation, or directed movement, of plants in response to a nonuniform, or directional, external stimulus is called a tropism. The term was formerly applied also to orientation in animals, such as amoebas and flatworms, that respond to stimuli in a similar-appearing way, but these responses are now properly called taxes and kineses. It is convenient to classify tropisms according to the nature of the stimulus: a response to light is called phototropism; to gravity, gravitropism (formerly called geotropism); to water, hydrotropism; to chemical stimulus, chemotropism; and to touch, thigmotropism. Tropisms are very important in determining the orientation of plants in space. Plant stems have a strong tendency to turn toward the light (positive phototropism) and away from gravity (negative gravitropism). Most roots grow toward gravity (positive gravitropism); if roots respond to light, they turn away from it (negative phototropism).

Phototropism was first rigorously studied in canarygrass and oat seedlings as early as 1880 by Charles Darwin and his son Francis. The Darwins found that it was the actively growing tip of the coleoptile, the sheath surrounding the young shoot, that perceived the phototropically active light, even though curvature was observed in the cells below the tip.

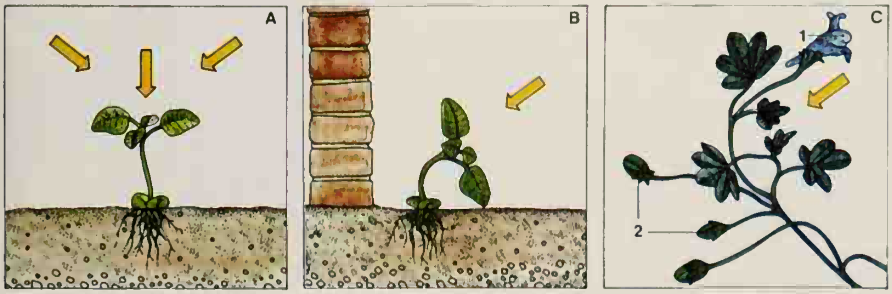
About 30 years later (1910–13) the Danish scientist P. Boysen-Jensen found that if a thin layer of gelatin was placed between the tip and the rest of an oat coleoptile, the coleoptile would still bend toward light. This suggested that a diffusible chemical, passing through the gelatin, was involved.

A few years later, in Hungary, A. Paál demonstrated that coleoptiles could be made to bend even in complete darkness if the tip was cut off and then replaced but offset to one side. The coleoptile always bent away from the side on which the tip was placed. Apparently that side of the coleoptile underneath the offset tip grew more rapidly than the other side.

The conclusive experiments were performed in Holland by F. W. Went in the late 1920s. Went showed that if the cutoff tips were allowed to stand on small, gelatinous agar blocks for a period of time in darkness, and the blocks were then placed offset on coleoptile stumps, the stumps would bend away from the blocks. Apparently a growth-stimulating substance was manufactured in the tips of the coleoptiles and collected by diffusion into agar blocks.

This hormonelike substance, called auxin, was subsequently identified as β-indoleacetic acid (IAA) (see hormone, plant). Auxin is produced in the tips of coleoptiles (or stems) and, moving downward, stimulates the cells below the tip to elongate. In darkness or under uniform illumination, the movement of auxin from the tip is uniform: all cells are stimulated to grow about the same amount, and the coleoptile (or stem) grows vertically. Nonuniform lighting establishes a differential in auxin flow, with more auxin flowing down the shaded side of the coleoptile (or stem). The cells on the shaded side thus elongate faster than those on the lighted side, forcing the coleoptile to bend toward the light.

One possible mechanism for controlling the amount of auxin flow was proposed by N. Cholodny and demonstrated experimentally by Went. The Cholodny-Went theory states



The involuntary response of plants to light is called phototropism. Plant shoots grow toward the light (positive) when cell growth is accelerated on the shady side. Roots and seedpods often grow away from light (negative). (A) A seedling exposed to light on all sides grows straight. (B) Light on only one side results in growth in that direction. (C) Whereas a flower (1) grows toward light, a seedpod (2) may grow away from it.

that unilateral, or one-sided, illumination interacts with the system transporting the auxin, causing it to divert the auxin toward the shaded side as it moves out of the tip. Went's experiments in support of this theory were confirmed and extended by W. R. Briggs during the 1960s.

Several important questions, however, remain to be answered if phototropism is to be completely understood. Because it is a response to light, there must be a pigment present to absorb the effective light. In the case of phototropism, the effective light is from the blue region of the spectrum. A comparison of the action spectrum of phototropism with absorption spectra of probable pigments indicates that both β-carotene and riboflavin may be involved.

Growth movements in response to gravity are called gravitropism. Roots are positively gravitropic, growing in the direction of the Earth's gravitational field. Shoots are negatively gravitropic, growing away from the gravitational field.

Many branches, leaves, and other structures grow at various intermediate angles to the gravitational field. Such behavior is called plagiotropism. A plagiotropic movement is shown by the creeping stems called rhizomes, which respond both gravitropically and phototropically and grow at right angles to gravity. Experiments have demonstrated that gravitropism is caused by differential auxin concentration, with more auxin collecting on the lower side of the shoot or root.

In roots, scientists believe that heavy starch-containing organelles called amyloplasts respond to gravity by settling in cells in the root tip. The pressure generated by the accumulation of amyloplasts triggers an increased auxin concentration in cells in the lower side of the root. Gravitropism helps the plant to best fill available space, sending the shoot upward for absorption of carbon dioxide and light, and the root system downward into the soil for absorption of water and minerals.

An excellent example of chemotropism is seen following pollination of flowers. Growth of the pollen tube down through the style toward the ovary is a chemotropic response, apparently to a gradient in calcium concentration. Thigmotropism is most readily seen in the tendrils of climbing vines or pea seedlings. The tendrils are stimulated to grow in the direction of physical contact with a solid object, and they tend to wrap around whatever structures they contact. This obviously assists the plant in obtaining necessary support.

Plant movements that are independent of the direction of the stimulus or that are caused by nondirectional stimuli are called nastic movements, or nasties. These include the closing or opening of flowers in daylight or darkness, actions believed to be influenced by light and temperature.

tropopause [troh'-poh-pawz] The tropopause is the boundary between the troposphere and STRATOSPHERE. In the troposphere the temperature generally decreases with height; above the tropopause, about 15 to 20 km (9 to 12 mi) in the tropics and about 10 km (6 mi) in polar areas, the temperature no longer decreases. In some instances it remains constant, and at other times or places it increases with height. The tropopause is relatively cold because of its distance from the chief absorbers of solar radiation above and below it: the Earth's surface and the OZONE LAYER.

troposphere [troh'-puh-sfeer] The troposphere, the lowest layer of the Earth's ATMOSPHERE, has for its upper boundary the tropopause and for its lower boundary the Earth's surface, where important heat and water-vapor fluxes occur (usually upward during the day and downward during the night). Virtually all weather, or short-term variation in the atmosphere, occurs in the troposphere, as well as considerable turning to turbulence—hence its name, derived from the Greek words *tropos*, "a turn," and *sphaira*, "ball." The troposphere contains 99% of the atmosphere's water vapor and 90% of the air. Air temperature in the layer decreases with increasing height, except when inversions occur.

Trotsky, Leon [traht'-skee] Leon Trotsky, b. Lev Davidovich Bronstein on Nov. 7 (N.S.), 1879, d. Aug. 21, 1940, was second only to Vladimir Ilich LENIN as organizer of the Bolshevik phase of the RUSSIAN REVOLUTIONS OF 1917. A charismatic orator, he was also a brilliant theorist whose writings greatly influenced socialist movements worldwide. His practical skills enabled him to plan the Petrograd uprising in November 1917 and to create the Red Army that saved the Bolshevik regime in the ensuing Civil War (1918–20). Independent and aloof, however, he failed to gain broad party support after Lenin's death in his unsuccessful struggle for power with Joseph STALIN.

Early Life and Revolutionary Activity. Trotsky, the son of a prosperous Jewish farmer, became a professional revolutionary at the age of 18. In exile in Siberia, he joined the Social Democratic party, and in 1902 he escaped abroad, met Lenin, and began his troubled relationship with the Bolshevik party (see BOLSHEVIKS AND MENSHEVIKS).

After 1903, Trotsky sided with the Mensheviks be-

Leon Trotsky, one of the leaders and major theoreticians of the Russian Revolution, organized the Red Army and served as Soviet commissar of foreign affairs and of war under Lenin. Exiled by Stalin, he was later assassinated.

cause he feared that Lenin's "elitist" organizational methods would lead to dictatorship. During the Russian Revolution of 1905, Trotsky played a leading role in the Saint Petersburg (later Petrograd) Workers' Soviet. Abroad again from 1907, he wrote extensively until he returned to Russia in 1917.

In his writings Trotsky argued that the first, "bourgeois" stage of revolution could be carried out only with the help of Russia's organized workers and that this stage would lead to a condition of "permanent revolution." The proletariat, who would have brought the bourgeoisie to power, would then gradually assume political control. As the revolution passed into worker hands in backward Russia, workers' revolts would spread to the more advanced capitalist societies of Europe and would establish socialist regimes to aid and protect the weak Russian revolutionary government.

Revolutionary Leader and Soviet Official. This outlook, soon to affect much Third World revolutionary thinking, structured Trotsky's activism in 1917. Returning to Russia independently of Lenin after the March 1917 revolution, he called on the workers to overthrow the liberal provisional government. In August he joined the Bolshevik party, whose longtime loyalists (including Stalin) regarded him as an interloper. However, Trotsky rapidly won a leading role with his spellbinding speeches and organizational energy. In September he was elected chairman of the Petrograd Soviet, and from that post he organized the Bolshevik forces that overthrew the regime of Aleksandr Kerensky.

Appointed commissar of foreign affairs (1917–18), and commissar of war (1918–25), Trotsky managed to organize an efficient Red Army, a truly remarkable feat; but his brusque style and his impatience with criticism and incompetence won him few friends.

Known as a "left Bolshevik" and an advocate of both rapid, planned industrialization and party democracy, Trotsky watched impatiently after 1921 as the party course seemed to support neither. In a series of essays labeled "The New Course" (1923), he bitterly criticized the growing bureaucratization of the party and argued for greater centralized planning. Much of his hostility was directed against Stalin, whom he loathed. In response, Stalin stated his own position by advocating "socialism in one country" (the antithesis of Trotsky's advocacy of world revolution). With Lenin's death in January 1924, Trotsky proved either too self-confident or too impatient to work carefully at practical politics. Within weeks he was censured for "factionalism," and within three years he was stripped of all posts and expelled from the party.

Exile. Condemned to internal exile in 1928, he was banished from the USSR the following year. Trotsky then lived in Turkey (1929–33), France (1933–35), Norway (1935–36), and Mexico (1936–40). He continued to write on a wide range of issues: culture, literature, politics, international affairs, revolutionary theory, and women. He completed his massive *History of the Russian Revolution* (3 vols., 1931–33; Eng. trans., 1932–33), also working energetically to expose Stalin—most notably in *The Revolution Betrayed* (1937). At the treason trials held (1936–38) in Moscow, Trotsky was denounced in absentia as the archconspirator against the Soviet regime. He was finally axed to death by a Stalinist agent at his home in a suburb of Mexico City.

trotter see HARNESS RACING; HORSE RACING

troubadour see MINSTRELS, MINNESINGERS, AND TROUBADOURS

trout Strongly colored, active fishes of cold or temperate lakes and rapid streams, the approximately 15 species of trout are grouped with the SALMON in the family Salmonidae. All but two of the genus *Salmo* are regarded as trout. Once limited to the Northern Hemisphere, they are valued as game and food fish and have been introduced into the Southern Hemisphere. Although trout are predominantly freshwater fishes, some species migrate to the ocean after spawning upriver.

The trout has a moderately long, unspecialized body that is laterally compressed, smooth, and muscular. Axial and paired fins are without spines. The softer, fleshy adipose fin, between the dorsal and caudal fins, is an indicator that the trout is a salmonid. All scales are small except for the elongated axial scale at the base of each pelvic fin.

The trout's diet changes with age. Fry, or newly hatched fish, feed on aquatic insect larvae for the most part. Adults eat mainly small fish, shrimp, and winged insects.

Many male and female trout return after maturing (3 to 4 years) to the same place they were hatched in order to spawn. Most trout breed in early spring in running water. The female lays her eggs in a depression she makes by vigorously vibrating her tail in the gravelly shallows. The nearby male discharges his sperm to fertilize approximately 200 eggs, which hatch in about 40 days. As

The rainbow trout (top), *native to the North American Pacific coast, is stocked in lakes throughout the world as a game fish. The lake trout* (bottom), *also popular among anglers, thrives in cold, deep lakes of the United States and Canada.*

many as 10,000 eggs may be laid per season by a single female. More than 90 percent of fry are killed during the first 3 to 4 months of life by predators.

One of the best-known trout is the brown trout, or sea trout, *S. trutta,* of Europe. These fish keep to the deeper pools and overhanging shelter of mountain streams. The Seven lake trout, *S. ischchan,* and the cutthroat trout, *S. clarkii,* have been able to invade new and changing mountain drainages and occupy ephemeral lakes. Both species, however, have been subjected to severe recent modifications of habitat and reduction of population by dams and other human constructions.

One of the most popular game fish is the rainbow trout, *S. gairdneri,* the several forms of which are native to American Pacific Coast streams. The rainbow trout gets its name from the broad band of red along its side.

For most trout populations, measures for control and conservation have been established through government agencies and associations. Artificially propagated fish are planted in order to provide extra catches for more anglers.

trout-perch Trout-perch (family Percopsidae) comprise two species of small, sandy-colored, nearly transparent fishes found throughout most of southern Canada and the northern United States. Trout-perch are easily recognized by the combination of coarse ctenoid scales, spines in the dorsal and anal fins, and the presence of an adipose fin. Although typically lake dwelling, they are sometimes found in turbid, cool streams. In lakes, trout-perch migrate at night from deep water into shallow to feed and are themselves important forage fish for the larger, commercially important species such as walleye, trout, and pike. Trout-perch spawn in the spring in streams and on shallow, gravelly lake bottoms.

Troy (archaeological site) The name *Troy* refers both to the remains of a Bronze Age fortress and city at Hissarlik in modern Turkey, near the entrance to the Dardanelles, and to the legendary city of King Priam that was destroyed by ancient Greeks in the TROJAN WAR. There are reasons to believe that the physical remains in Turkey correspond, in part at least, to the city in Greek literature. Troy was once known also as Ilios or Ilion; this is reflected in the name of Homer's epic poem the *Iliad,* a work that claims to relate the story of Troy's fall.

Troy was rediscovered and excavated by Heinrich SCHLIEMANN (1870–90) and, after his death, by his colleague Wilhelm Dörpfeld (1893–94). Within the mound of archaeological layers (strata) at the site, which reaches a depth of more than 15 m (50 ft), Schliemann and Dörpfeld distinguished nine major divisions (Troy I–IX).

The earliest settlement, Troy I, lasted about 500 years (3000–2500 BC); it was a small fortress enclosed by a strong wall. Houses were built with foundations of stone and walls of clay-brick. The settlers knew of copper but normally used bone and stone for tools and weapons. Most of their surviving possessions are of earthenware pottery. Troy I, like many other ancient settlements, came to its end in a devastating fire.

Excavations of the ancient city of Troy, in Hissarlik, Turkey, were begun (1870) by Heinrich Schliemann. Stratigraphical research has revealed nine levels at Troy, the earliest dated at 3000 BC.

Troy II (2500–2200 BC) possessed much gold and silver and made much more use of copper. Its artisans were more advanced; the potter's wheel, for example, appeared at Troy during phase II, when the Trojans were in contact with both the Aegean world to the west and central Anatolia to the east. Troy's power and wealth were probably derived from its strategic position, controlling important trade routes between Asia and Europe.

The high point of Troy's history was Troy VI (1800–1300 BC). The area enclosed by the citadel was then about 230 m (750 ft) across, with finely crafted stone walls and stoutly fortified gates. Once again, the rulers of Troy occupied a position of power and importance in relation to the neighboring peoples of the Aegean and Anatolia.

Troy VI was destroyed by earthquake. Troy VIIa (1300–1200 BC), resettled by the survivors of Troy VI, depended on the same fortifications. Its houses were crowded together; many had large storage jars sunk beneath the floors. The impression is that of a community under stress, possibly like Priam's citadel, the siege of which figures in the *Iliad* and other stories of the Trojan War. According to Greek tradition, Troy fell in 1184 BC. The archaeological evidence supports a date of about 1200 BC for the destruction of Troy VIIa. Resettlement followed on a small scale during Troy VIIb (1200–1100 BC).

Thereafter, the site seems to have been deserted for about four centuries. In about 700 BC new settlers appeared, and a city of modest size grew up over and around the ruins of the Bronze Age fortress. During the Hellenistic and Roman eras, efforts were made to rehabilitate the ancient site, which became important mainly as a tourist attraction. It is not known to have survived beyond the 4th century AD, but its memory remained influential on the Western imagination.

Troy (New York) Situated in eastern New York on the east bank of the Hudson River, almost across from Albany, Troy is the seat of Rensselaer County. It has a population of 54,269 (1990). Once a prominent industrial center, the city has experienced a decline in manufacturing. Rensselaer Polytechnic Institute (1824) and Russell Sage College (1916) are there. The area near Troy was explored by Henry Hudson in 1609, and the site itself was included in a patroonship granted to Kiliaen Van Rensselaer by the Dutch West India Company in 1629. The city was laid out in 1786.

troy weight see WEIGHTS AND MEASURES

Troyes [twah] The French city of Troyes (1982 pop., 63,581) lies on the Seine River, about 150 km (95 mi) southeast of Paris. It is a road and rail junction and the home of the French hosiery industry. Landmarks include the Gothic Cathedral of Saint-Pierre et Saint-Paul (begun 13th century). Dating from pre-Roman times, the city was a prosperous medieval commercial center. It was the seat of the counts of Champagne from the early 11th century and the site of the Champagne fairs (12th–13th centuries). A stronghold of Protestantism, Troyes declined after the revocation of the Edict of Nantes in 1685 drove away many of its commercial leaders.

Trucial States see UNITED ARAB EMIRATES

trucking industry The trucking industry is made up of those persons and firms engaged in the business of owning and operating motor trucks for hire to transport products over roads. Such companies are known as carriers.

Classification of Carriers

The three principal categories of carriers are: private carriers, who use trucks to transport only their own products from farm to market, or raw materials from source to processing or manufacturing plants, or finished products to their markets, or for interplant movements; contract carriers, who enter into contractual agreements, usually long-term in nature, with business establishments to transport materials and products for those firms; and common carriers, who serve the general public on any and all commodities. A contract carrier may contract with several firms; however, shipments from different firms cannot be mixed together. Common carriers are granted operating certificates by the INTERSTATE COMMERCE COMMISSION (ICC) as either irregular-route carriers or regular-route carriers.

Irregular-route carriers serve the public on "call and demand." They usually operate from a central office or terminal, shipping commodities from specified points or areas to other specified areas.

Regular-route common carriers are granted authority by the ICC to operate over specified highway routes on a regular basis. Commodities handled by regular-route carriers may be specified, or the carrier may have authority to handle general commodities, usually with some exceptions. Such special goods include small-package express, armored express (for transporting items of unusual value), household goods, automobiles, and explosives.

Agricultural produce (unprocessed farm products) is not subject to ICC regulation and may be handled by what are known as unregulated motor carriers.

History

In the late 1920s and early 1930s the trucking industry, which was dominated by large numbers of itinerant owner-operators, was considered by many to be unstable, chaotic, and in need of economic regulation. The National Industrial Recovery Act (NRA) of 1933 brought together two organized groups of trucking officials to develop a code of fair competition and led to the formation of the American Trucking Associations. The organization submitted its code to the NRA in 1934. Every for-hire carrier was required to observe maximum hours of labor and minimum wages for all employees. The Motor Carrier Act of 1935 provided for safety regulation of interstate carriers, as well as economic regulation of for-hire carriers under the authority of the Interstate Commerce Commission (ICC).

Regulation and Deregulation

Under ICC regulation, operators with for-hire trucks who wished to carry freight into interstate markets had to apply to the ICC for a license to do so. Licenses were granted only if the need for additional truck capacity could be proved, and permission often also included the obligation to serve less profitable markets within the license region. In addition, the types of freight that could be carried by any one ICC-licensed truck were limited, with some commodities—such as food—under severe regulatory restrictions. Exemptions from ICC regulation were extended only to certain independent owner-operators, farmer cooperative truckers, and private carriers serving only their parent companies.

The setting of trucking rates, which had been a matter between the individual trucker and the customer, gave way to the establishment of rate bureaus, which are owned and supported by all participating carriers. The bureaus researched and analyzed costs in order to establish competitive rates for the industry. Such an arrangement was made possible by a Justice Department antitrust exemption giving regulated trucking firms the power to collectively set rates subject to approval by the ICC.

In 1980, however, Congress passed a trucking deregulation bill in the hope of increasing competition within the industry—and therefore saving consumers about $5 billion annually by reducing shipping costs. By removing many of the ICC regulations, the bill made entrance into the industry easier for new trucking firms, gave individual truckers greater rate-setting powers, and ended some types of collective rate making.

Since deregulation the ICC has granted licenses to about 3,000 new carriers and approved 35,000 requests for expansion of routes—a vast increase over earlier approvals.

Truck weight and size limits on interstate highways are regulated by the states, although they may not exceed the federally set maxima: a gross weight of 36,000 kg (80,000 lb) and 18.3 m (60 ft) in length and 2.4 m (8 ft) in width.

Types

The pickup truck has a carrying capacity of 0.5 to 5 U.S. tons. Smaller types usually have a conventional design, whereas larger sizes have the cab situated over the engine. The loading area is designed for the particular job to be performed.

The panel truck is a completely enclosed van having a capacity of about 0.5 U.S. tons. The straight truck may have a conventional or cab-over-engine design. The body length is designed for the job function. Where double- and triple-trailers are used, the straight truck may be used as the tractor, with the trailer or trailers coupled behind.

The tractor may have a conventional or cab-over-engine design. It has a so-called fifth wheel and may have rear dual wheels mounted on a single axle, or tandem axles, depending on the usage.

The semitrailer is a vehicle designed to be pulled by a tractor. It has either single or tandem axles on the rear. A steel plate with a welded or molded pin that is located on the bottom front slips and locks into the fifth wheel of the tractor.

The full trailer is similar to the semitrailer except that it has front wheels as well as rear wheels and has a tongue for hooking it to a tractor or another trailer. A tandem unit consists of two trailers pulled behind a single tractor. They are generally not allowed on small or congested roads.

Trucks that are even more specialized include FIRE ENGINES, refrigerated vans, EARTH-MOVING MACHINERY, dump trucks, concrete mixers, garbage trucks, and tank trucks.

The Industry Today

In the late 1980s there were over 40 million trucks of all sizes registered in the United States. Only about one million were combination tractor-semitrailers, the standard vehicles used by the trucking industry. Compact pickups, station wagons on truck chassis, and minibuses represented the largest increase in numbers, as many car owners purchased small trucklike vehicles. Truck industry revenues totaled over $200 billion annually, the product of over 600 billion ton miles of freight carried. The industry employed about 8 million people, making it the largest private industrial employer.

Trudeau, Garry [troo'-doh] Garry Beekman Trudeau, b. New York City, 1948, creator of the popular "Doonesbury" cartoon, became the first comic-strip artist to win (1975) the Pulitzer Prize for editorial cartooning. Satirizing public figures and politics, "Doonesbury" appeals mostly to young adults. Trudeau suspended the strip from Jan. 1, 1983, to Sept. 30, 1984; on its return, it appeared in about 775 newspapers. The strip has often been collected and published in book form. With Elizabeth Swados as composer, Trudeau wrote the Broadway musical *Doonesbury* in 1983.

Trudeau, Pierre Elliott Pierre Elliott Trudeau, b. Montreal, Oct. 18, 1919, served as prime minister of Canada from 1968 to 1979, and again from 1980 to 1984. Trudeau was first elected to the House of Commons in 1965. After serving (1967–68) as minister of justice and attorney general of Canada he succeeded (1968) Lester Pearson as prime minister and Liberal party leader.

Trudeau won a landslide electoral victory in 1968 and began a program to effect greater independence from the United States. He greatly expanded Canada's contacts with the USSR and with developing countries, recognized (1970) China and withdrew half of Canada's NATO troops from Europe.

A confirmed federalist, Trudeau—aided somewhat by his French background—attempted to blunt the separatist movement in Quebec by sponsoring the Official Languages Act (1969), making French-language services available in all federal government operations. In 1970, to counter separatist terrorism, Trudeau briefly imposed martial law. Trudeau's party lost its parliamentary majority in 1972, and his government survived only through a shaky coalition with the New Democratic party. The Liberals again achieved a majority in 1974, but Trudeau's popularity continued to decline, and the Liberal government was defeated in May 1979.

After announcing his resignation as Liberal leader, Trudeau was persuaded to lead the party in new elections in February 1980. He returned as prime minister after the Liberals won an overall majority. He soon faced strong provincial challenges to federal authority. A proposal of autonomy for Quebec was defeated in a referendum in May 1980, but Alberta, in turn, challenged government policy on oil pricing. Trudeau's formula for revising the federal constitution was opposed by most provincial premiers until a compromise was reached—with only Quebec dissenting—in November 1981. The new Constitution Act became law in April 1982. Trudeau resigned as prime minister on June 30, 1984.

Pierre Elliott Trudeau served as Canada's prime minister for a second time (1980–84), returning to the post he had previously occupied for more than a decade (1968–79). Trudeau, leader of the nation's Liberal party, promoted Canadian control of its own economy and struggled to quell the secessionist movement in French-speaking Quebec.

Truffaut, François [troo-foh'] An important force in French filmmaking for more than 25 years, François Truffaut, b. Feb. 6, 1932, d. Oct. 21, 1984, began his cinematic career as a critic (1951–59) for the film journal *Cahiers du Cinéma*. He started directing in the mid-1950s, most notably the short film *Les Mistons* (The Mischief Makers, 1958). His first full-length film, *The 400 Blows* (1959), featuring his cinematic alter ego Antoine Doinel, immediately established him as a leader of French NEW WAVE cinema. Later films in the continuing Doinel series include *Love at Twenty* (1962), *Stolen Kisses* (1968), *Bed and Board* (1970), and *Love on the Run* (1978).

Truffaut explored a variety of film genres in *Shoot the Piano Player* (1960) and *The Bride Wore Black* (1967), takeoffs on FILM NOIR; *Mississippi Mermaid* (1969), in which Truffaut superimposes his own romantic stamp on a conventional mystery framework; and the science-fictional *Fahrenheit 451* (1966). *Jules and Jim* (1961), with its successful blend of narrative and structural approaches, is considered his masterpiece.

In his later work Truffaut was drawn into studies of human motivation and excessive passion, as exemplified by *The Wild Child* (1970), in which he appeared as Dr. Itard, and the hauntingly beautiful *The Story of Adèle H.* (1975), which traces the pathological career of Victor Hugo's daughter. Truffaut perhaps best expressed his elegance and irony in the Pirandellian *Day for Night* (1973). His last films include *The Last Métro* (1980) and *Confidentially Yours* (1984).

truffle [truhf'-uhl] The truffle is a pungent wild fungus, highly prized as a food delicacy. The name is popularly used to describe both the fungus and its fruiting bodies (see FUNGI). The truffle fungus is believed to have a symbiotic relationship with the roots of trees, particularly oak and beech trees. Trained dogs or pigs are used to detect truffles. Agronomists have not been successful in cultivating them. The edible part of the truffle is a spore-producing fruiting body that grows about 0.3 m (1 ft) underground. Most culinary truffles belong to the genus *Tuber* and are found in western Europe, although North Africa also produces a truffle in some quantity. *T. melanosporum* is the famed black Périgord truffle of France; the white truffle, *T. magnatum*, grows in the Italian Piedmont area.

Trujillo, Rafael [troo-hee'-yoh] Rafael Leonidas Trujillo Molina, b. Oct. 24, 1891, d. May 30, 1961, was dictator of the Dominican Republic. A participant in the coup against President Horacio Vásquez in 1930, Trujillo ran unopposed for president later that year. By keeping a firm grip on the army, he dominated the government completely for the rest of his life. He was president until 1938 and then again from 1942 to 1952. After 1952 he gave the position to his brother, Hector, but he retained power behind the scenes.

Trujillo's reign was despotic and cruel, although he did bring public order and economic stability to the island. Opposition grew, especially among Caribbean neighbors, and the Organization of American States finally voted to ostracize and censure him. He was assassinated by army leaders.

Truly, Richard H. Richard Harrison Truly, b. Fayette, Miss., Nov. 12, 1937, was the first ASTRONAUT to become administrator of NASA (see NATIONAL AERONAUTICS AND SPACE ADMINISTRATION). A graduate of the Georgia Institute of Technology in 1959, he joined the navy and served as an aircraft-carrier pilot and an instructor at the air force's test pilot school. Advancing to the rank of rear admiral, he was transferred to NASA's astronaut corps after cancellation of the air force's Manned Orbiting Laboratory program. Truly conducted suborbital test flights for the SPACE SHUTTLE program in 1977 and took part in two Shuttle missions in 1981 and 1983. He then left NASA to head the new Navy Space Command but returned to command the Shuttle program in 1986 following the *Challenger* disaster. In 1989 he was named head of NASA.

Truman, Harry S. Harry S. Truman, 33d president of the United States (1945–53), carried on the New Deal reform tradition and committed the nation to the containment of Soviet power. His policies shaped American politics and diplomacy for a generation.

Early Life and Career. Truman was born on May 8, 1884, in Lamar, Mo. and spent his early life in Independence, Mo., near Kansas City. After serving in France during World War I, he entered politics as an ally of Thomas J. PENDERGAST's Kansas City Democratic machine; Truman won election to the Jackson County Court (county commission) in 1922. Defeated in 1924, he was elected presiding judge in 1926 and held the office for eight years.

In 1934, Truman was elected to the U.S. Senate and was barely reelected in 1940. In 1941, however, Truman became chair of a special Senate committee investigating World War II military spending programs. Widely praised for his committee work and liked throughout the Democratic party, he was chosen for the Democratic vice-presidential nomination in 1944, replacing Henry A. WALLACE. He became president when Roosevelt died on Apr. 12, 1945.

Presidency: First Term (1945–49). With Germany's surrender (May 8, 1945), differences with the USSR began to come into the open. Determined to dominate Eastern Europe and control at least a portion of Germany, the Soviet government claimed the prerogative of establishing spheres of influence in violation of the principles of democracy and self-determination that had justified the war for most Americans. In July the POTSDAM CONFERENCE, Truman's only personal meeting with Joseph Stalin, provided no settlement. While at Potsdam, Truman authorized the use of the ATOMIC BOMB against Japan. After the bombing of Hiroshima (August 6) and Nagasaki (August 9), Japan surrendered unconditionally on Aug. 14, 1945.

When the war ended, relations with the USSR degenerated into a COLD WAR. The USSR supported a Communist-led insurrection in Greece, pressured Turkey for con-

AT A GLANCE

HARRY S. TRUMAN
33d President of the United States (1945–53)

Nickname: "Give 'Em Hell Harry"
Born: May 8, 1884, Lamar, Mo.
Education: University of Kansas City Law School
Professions: Farmer, Public Official
Religious Affiliation: Baptist
Marriage: June 28, 1919, to Elizabeth Virginia Wallace (1885–1982)
Children: Mary Margaret Truman (1924–)
Political Affiliation: Democrat
Writings: *Memoirs* (2 vols., 1955-56)
Died: December 26, 1972, Kansas City, Mo.
Buried: Independence, Mo.
Vice-President: Alben W. Barkley (1949-53)

Harry Truman

trol of the straits between the Black Sea and the Mediterranean, refused to withdraw wartime troops from northwestern Iran, and rejected an American proposal for United Nations control of atomic energy.

Truman countered with a policy of containment. In March 1946, reacting in part to U.S. demands, the USSR pulled out of Iran. In March 1947, Truman asked Congress to vote heavy military and economic aid to Greece and Turkey and proclaimed the policy that became known as the Truman Doctrine—a program of assistance to countries resisting outside domination. The administration in 1947 also formulated the MARSHALL PLAN, an expensive, comprehensive program for the reconstruction of Western Europe. Partly in response the Russians blockaded (June 1948–May 1949) the Western sector of Berlin but were unable to force U.S. withdrawal. Instead, the United States and the major non-Communist European nations negotiated the North Atlantic Treaty, forming NATO (see NORTH ATLANTIC TREATY ORGANIZATION), in 1949. Also in 1949, Truman introduced in Congress the POINT FOUR PROGRAM of technical aid for backward areas, intended to check the spread of communism.

Truman's domestic proposals, known as the FAIR DEAL, included broad social-welfare reforms. Willing to intervene extensively in the economy, Truman supported economic controls in times of emergency and backed legislation to underwrite full employment. He ordered (1948) the desegregation of the armed forces, let the Justice Department support African Americans in civil rights cases, and was the first president since Reconstruction to have a legislative civil rights program.

On the whole, though, Truman's domestic legislation fared poorly. A Democratic Congress rejected most of his proposals in 1945–46; its most important accomplishment, the Employment Act of 1946, established the Council of Economic Advisers but failed to guarantee full employment. During the period of severe postwar inflation, Truman's attempts to prevent major strikes, including seizure of the coal mines during a 1946 walkout, alienated labor unions, while his efforts to maintain price controls angered business and agricultural interests. In September 1946, Truman dismissed Secretary of Commerce Henry A. Wallace for criticizing the administration's tough line toward the USSR. The result was further division in a Democratic party already divided by Southerners' anger over Truman's civil rights program. Consequently, the Democrats lost the congressional elections of 1946. In 1947–48, Truman regained labor support with his unsuccessful veto of the Taft-Hartley Act (or LABOR-MANAGEMENT RELATIONS ACT), and he spiritedly denounced as reactionary a Republican Congress that would not pass his domestic programs.

In the election of 1948, Truman faced opposition not only from Republican Thomas E. DEWEY but also from left-wing and southern factions of his own party that backed the Progressive candidate, Wallace, and states' righter (Dixiecrat) Strom THURMOND. Barnstorming the country, Truman pleased crowds with his peppery "give 'em hell" style. He won a narrow but startling upset victory with 49.5 percent of the vote to Dewey's 45.1 percent. The Democrats, moreover, regained control of Congress.

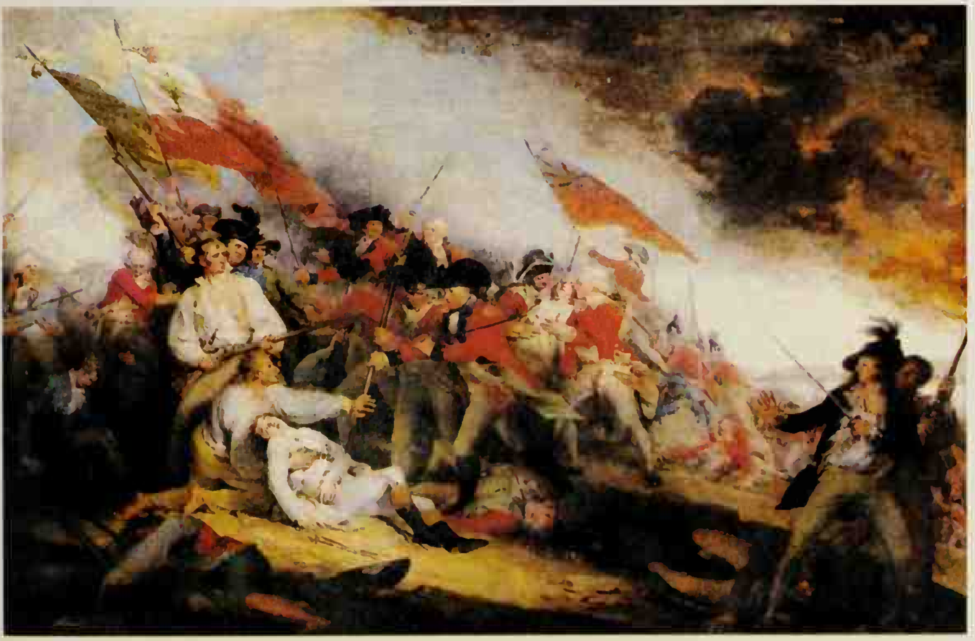
Presidency: Second Term (1949–52). By the end of 1949 reverses in the cold war had made communism the nation's major domestic issue. In mid-1949 the Chinese Nationalist government of CHIANG KAI-SHEK retreated to Taiwan, abandoning the mainland to the Communists. The Truman administration had sharply reduced U.S. aid to the corrupt and inefficient Nationalists and in the eyes of many was responsible for the loss of China. Almost at the same time, moreover, the administration announced that the USSR had tested its first atomic bomb. Shortly thereafter came a stunning series of Communist espionage cases, including those of Alger HISS and Julius and Ethel ROSENBERG, that involved U.S. atomic secrets and possible penetration of sensitive government offices. Although Truman had authorized a stringent program of loyalty investigations of federal employees in 1947, he now came under wide attack. In early 1950, Republican Sen. Joseph R. MCCARTHY assumed leadership of the assault with repeated charges of Communist infiltration of the State Department and other key government agencies. With McCarthyism flourishing, Congress passed (1950), over Truman's veto, the MCCARRAN ACT, which restricted the civil rights of Communists.

Truman's prompt intervention in response to the invasion of South Korea by the Communist North in June 1950 brought him only more difficulties. By early 1951 the KOREAN WAR was at a frustrating stalemate. The president dismissed Gen. Douglas MACARTHUR for advocating drastic military measures against the Communists and, as a result, faced widespread disapproval. When Truman seized the steel industry in 1952 to avoid a strike and maintain defense production, the U.S. Supreme Court declared the seizure unconstitutional.

Further weakened by discoveries of corruption in his administration, Truman announced in March 1952 that he would not run for reelection. Adlai E. Stevenson, his choice for the Democratic presidential nomination, lost the election to Dwight D. Eisenhower. Truman died on Dec. 26, 1972.

Trumbull, John An American painter whose works record the people and events connected with the nation's founding, John Trumbull, b. Lebanon, Conn., June 6, 1756, d. Nov. 10, 1843, was the son of Connecticut's governor and among the first educated, native-born Americans to dedicate themselves to painting. Hoping to ennoble art through his pictorial documentation of the American Revolution, Trumbull took part in the war as an aide-de-camp to George Washington and personally knew the patriots and leaders of the period.

Trumbull studied with Benjamin West in London and while abroad produced some of his best paintings—a series of small-scale portraits of Americans and several historical scenes. *The Battle of Bunker's Hill* (1786; Yale University Art Gallery, New Haven, Conn.), composed of many figures in close combat, is organized along a sweeping diagonal; the dramatic contrasts of light and shadow culminate in the highlighted soldier dying in the arms of a comrade.



John Trumbull's The Battle of Bunker's Hill *(1786) is typical of his representations of scenes from the American Revolution in its emotional intensity and nationalistic subject. Dramatic lighting, careful composition, and forceful movement emphasize the focal point, the death of a soldier. (Yale University Art Gallery, New Haven, Conn.)*

Trumbull's hopes of becoming his nation's official history painter were frustrated until 1817, when Congress commissioned him to paint four scenes from the war for the Rotunda of the Capitol—a project Trumbull had conceived about 30 years earlier. Unfortunately his talents were no longer equal to the task. One of these scenes, *The Declaration of Independence* (1818), is an example of the rather dry and mechanically executed work of his later career.

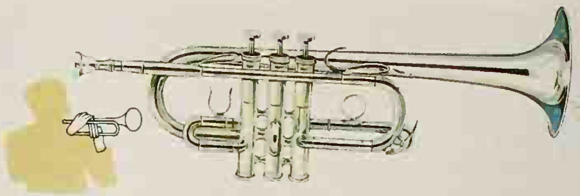
Trumbull, Jonathan Jonathan Trumbull, b. Lebanon, Conn., Oct. 12, 1710, d. Aug. 17, 1785, a merchant and governor of Connecticut (1769–84) during the American Revolution, was the only colonial governor who supported the independence movement. With Trumbull's leadership, Connecticut provided important supplies for the Continental Army.

Trumbull, Lyman Lyman Trumbull, b. Colchester, Conn., Oct. 12, 1813, d. June 25, 1896, was a leading Republican politician during the Civil War and Reconstruction era. Settling in Illinois as a young man, he was elected to the U.S. Senate in 1854.

Trumbull was known as an able constitutionalist and a man of conscience. Originally a Democrat, he became a Free-Soil Republican. A strong supporter of the Union war effort, he nevertheless criticized Abraham Lincoln's wartime use of executive power. Although opposed to Andrew Johnson's Reconstruction policies, Trumbull was one of seven Republicans who voted against convicting Johnson during the Senate impeachment trial. Dismayed by Republican corruption under the Grant regime, he joined the Liberal Republican bolt in 1872, subsequently returning to the Democratic party. He left the Senate in 1873.

trumpet A trumpet is a tube whose enclosed air column is vibrated by buzzing the lips on a mouth hole or mouthpiece. This tube originally was a hollow log or bone, then a cane, and ultimately a metal or ivory instrument. The loud blasts of these primitive instruments banished evil spirits and summoned gods. In later periods the trumpet was used in ritual and war.

By 1400 the unwieldy Western straight trumpet was often bent into an S shape. By 1500 the S shape was condensed to the contemporary single-form loop, which resembles the trumpet of Claudio Monteverdi and J. S. Bach. The 7-ft (2.1-m) tube pitched in D (with attachable C-loop) was designed to produce well-articulated pitches through the fourth octave of the harmonic series. The natural trumpet, although difficult to master, could be used with brilliant and impressive melodic effect in its highest (clarino) range. Trumpets were traditionally reserved for royalty, who created restrictive guilds to guard the privilege and prestige of clarino trumpeters.



The modern trumpet emits clear, ringing tones when air in its brass bore is set in vibration. The three valves direct air through the instrument's tubing, varying the pitch by altering the length of the air column. Playing position is shown (left).

In the classic period (late 18th century), the demanding clarino technique became outmoded. Trumpets were shortened, which placed the five remaining usable partials in the treble range, first to F with crooks from E to C, then to the presently standard B-flat with A-slide. Valves, first applied in 1824, did not achieve their full melodic potential until the later 19th century.

Recently a 4-ft (1.2-m) trumpet in high C has been adopted by many orchestral musicians, and trumpets in high D, F, and piccolo B-flat are used for performances of baroque music. A cone of wood or fiber, called a mute, is often used with the trumpet to produce special effects.

trumpeter Trumpeters are three species of large, mostly black birds known for their deep, loud, trumpetlike cry. They are classified in the genus *Psophia*, family Psophiidae, and are found in tropical forests of South America. They are thought to be related to cranes and rails and are placed with them in the order Gruiformes. Trumpeters are pheasant-sized—43 to 53 cm (17 to 21 in) long—with a moderately long neck, rounded wings, long legs, and short tail. The head is small and rounded, and the bill stout and slightly downcurved. The plumage has a velvety appearance on the head and neck. The common trumpeter, *P. crepitans*, has gray on the wings and back; the white-winged trumpeter, *P. leucoptera*, is white on the wings, and the green-winged trumpeter, *P. viridis*, is green on the wings and brown on the back. Highly gregarious, trumpeters gather in flocks of up to 20 birds on the forest floor.

truss A truss is a structure used in engineering or architecture that is formed by connecting the ends of straight pieces of metal or wood to form a series of triangles lying in a single plane. The design of a truss is based on the principle that a triangle is a rigid configuration that cannot collapse or change its shape unless the length of one of the sides is changed.

The first trusses were most likely made of wood and used for building homes and roofs. During the 18th and early 19th centuries cast and wrought iron were used, and later in the 19th century steel became the preferred truss material.

Trusses are used for the construction of railroad bridges, iron-frame buildings, roof and floor systems, certain industrial machines, and aircraft and automobile frames.

trust In law, a trust is a form of property ownership in which one person agrees to hold property for the benefit of another. The person holding the property is called the trustee, and the person who benefits is called the beneficiary. (For information on the trust as an entity in business and industry, see CARTEL; MONOPOLY AND COMPETITION.)

Fiduciary Relationship. The duty of the trustee is to manage the property solely in the interest of the beneficiary. This is called a fiduciary relationship because the trustee is expected to act in good faith and to work loyally for the interest of the beneficiary. The beneficiary has no power or right to tell the trustee how to perform his or her tasks—for example, what stocks or bonds to buy or sell. The trustee is regarded as the legal owner of the property, the beneficiary as the equitable owner. Thus in the eyes of the law the trust involves dual ownership: the trustee has the right to administer the property, and the beneficiary has the right to enjoy its benefits. If the beneficiary believes that the trustee is not acting in his or her best interests, the only recourse is to file a lawsuit against the trustee.

Origin of the Trust Concept. The trust institution exists only in Great Britain, the United States, and other countries whose legal systems are derived from British COMMON LAW. The origin of the trust concept lies in the dual system of courts that grew up in England. In addition to the traditional judicial system, a separate and somewhat competing entity, the court of chancery or EQUITY, also developed. The traditional law courts treated the trustee as the owner of the property. If a beneficiary claimed that the trustee had not fulfilled his duty to hold the property in trust for the beneficiary, the latter could get no relief in the law courts. The court of equity, however, was willing to step in and prevent the trustee from handling the property in any way other than for the advantage of the beneficiary.

The Testamentary Trust. A trust created in a WILL is called a testamentary trust. Such a trust is most commonly used in family situations. For example, a parent who has successful business investments may have several small children and wish to leave the property, upon his or her death, to the surviving spouse and the children. If the spouse does not want the responsibility of managing the property, and the children are too young to do so, the parent, in his or her will, can leave the property to a trustee, such as a bank. The bank will be instructed to invest and reinvest the property as it deems best. It will pay out the income from the property to the surviving spouse for life, and then to the children until they reach a certain age, such as 25. After that it will turn the property over to the children, and the trust will terminate.

The Inter Vivos Trust. In the foregoing example the parent created the trust in his or her will, to take effect upon death. Trusts also may be created *inter vivos*, a Latin phrase used by lawyers that means "between the living." Thus he or she could have transferred the property to the bank in trust while still alive. The bank would have paid the income to the parent until he or she died, and then to the surviving spouse and children.

The creator, or settlor, of an *inter vivos* trust may retain the right to revoke the trust at any time. If the creator does retain that right it is called a revocable trust. A revocable trust is, in effect, a conditional gift to the beneficiaries, because it may be revoked at any time by the settlor.

The trust arrangement is also used in a variety of situations in which it seems desirable to separate the management and control of property from its beneficiaries. A trust may be established for charitable purposes, such as providing scholarships for needy students. Pension trusts are established by business firms to provide retirement benefits for their employees. Insurance trusts can be used to hold insurance policies and to dispose of the proceeds upon the death of the insured. Another reason trusts are instituted is to prevent estate shrinkage through debts, taxes, and expenses.

Trustees. Because of the broad powers given to the trustee, selection of the trustee is done with great care. Commercial institutions have arisen that engage specifically in the business of acting as trustees. They are paid a fee out of the income of the trust. Usually such commercial trustees are also engaged in the banking business. In the United States approximately 3,000 institutions—banking and nonbanking—act as trustees.

trust territory A trust territory is a territory that is administered by another country under supervision of the United Nations Trusteeship Council. The council is composed of member nations that administer trust territories and permanent nonadministering Security Council members. Each trust territory has been governed by the provisions of a trusteeship agreement. Such an agreement usually gave the administering state full legislative, administrative, and judicial powers over the territory.

The 11 trust territories established after World War II were former German colonies in Africa and the Pacific that had been administered by various countries under the mandate system of the League of Nations between World Wars I and II (with the exception of former Italian Somaliland, returned to Italian administration as a trust territory in 1950). Unlike the mandate system, the system of trust territories was intended to advance the indigenous inhabitants toward self-government. By 1975, ten of the trust territories had gained independence or chosen to become part of other nations. The British-administered trust territory of TOGOLAND merged with the Gold Coast (now Ghana) in 1956, while French-administered Togoland became the independent nation of Togo in 1960. Also in 1960, Italian-administered Somaliland merged with the British protectorate of Somaliland to form independent Somalia, and French-administered Cameroons became the independent nation of Cameroon. In 1961 the southern part of British-administered Cameroons voted to unite with Cameroon; the northern part voted for union with Nigeria. Tanganyika, also administered by Great Britain, gained independence that same year (see TANZANIA). Belgian-administered Ruanda-Urundi divided into the nations of Rwanda and Burundi in 1962. Western Samoa, administered by New Zealand, gained independence in 1962; independence came in 1968 for Nauru, administered by Australia and on behalf of New

Zealand and Great Britain. Australian-administered New Guinea was united administratively with the Australian dependency of Papua in 1949; the two gained independence as Papua New Guinea in 1975. The sole remaining trust territory is the U.S.-administered Trust Territory of the Pacific Islands (see PACIFIC ISLANDS, TRUST TERRITORY OF THE).

trustee see TRUST

Truth, Sojourner Sojourner Truth, b. Hurley, N.Y., *c.*1797, d. Nov. 26, 1883, was an American preacher, abolitionist, and feminist. Born into slavery and given the name Isabella Baumfree, she ran away when her master refused to acknowledge New York's emancipation act of 1827. After settling in New York City, she adopted her new name as symbolic of her spiritual mission. In 1843 Sojourner Truth took up the struggle for black emancipation and women's suffrage, becoming the leading black woman orator. After the U.S. Civil War she continued to work on behalf of both blacks and women.

Sojourner Truth was a charismatic evangelist who traveled through the United States during the 19th century preaching on behalf of abolition of slavery and women's rights. Born into slavery and unable to read or write, she acted in obedience to visions and voices she claimed to receive. After the Civil War she helped in the resettlement of emancipated slaves.

trypanosomiasis [truh-pan-uh-soh-my'-uh-sis] Trypanosomiasis is a disease caused by parasitic protozoans of the family Trypanosomidae, which also contains the protozoans that cause LEISHMANIASIS. In humans, two variations of *Trypanosoma brucei*—*T. b. gambiense* and *T. b. rhodesiense*—cause African sleeping sickness; *T. cruzi* causes Chagas's disease, or South American trypanosomiasis. Both *T. brucei* and *T. vivax*, which cause animal trypanosomiasis in Africa, have spread to South America.

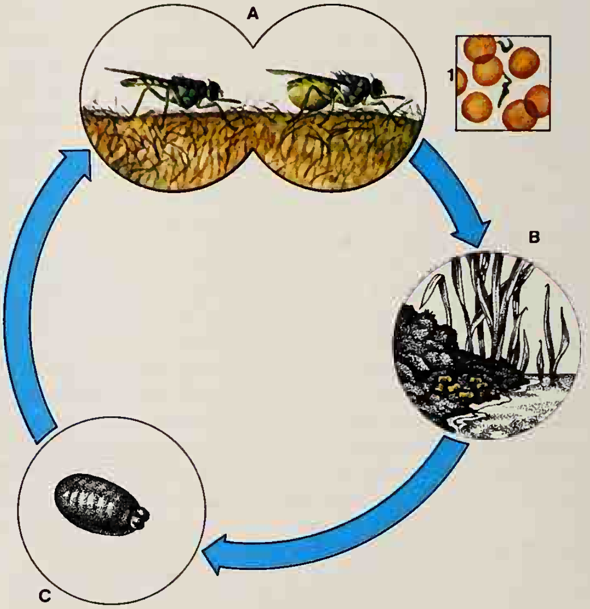
African sleeping sickness is transmitted by the bite of an infected TSETSE FLY. In humans the first symptom is a local inflammation at the site of the bite. Systemic symptoms follow, such as fever and chills, headache, edema, and enlargement of the lymph glands. Damage to the central nervous system may take years to develop, but it is manifested by sleepiness, lethargy, headache, and eventually motor disturbances, convulsions, and coma; without treatment, the disease is fatal. Antimicrobial agents are effective against trypanosomiasis if given early in the disease.

Chagas's disease is transmitted to humans by a predatory bug, *Triatoma*; the bite wound is contaminated by the insect's feces, which contain the parasite. *T. cruzi* is carried by both wild and domesticated animals. The disease is characterized by fever, spleen and liver enlargement, and nervous-system and heart-muscle damage. The acute form of the disease is usually confined to children and can be fatal. No universally effective treatment exists.

Ts'ao Hsüeh-Ch'in see CAO XUEQIN

tsetse fly [tset'-see] Found only in Africa, primarily south of the Tropic of Cancer, tsetse flies are two-winged flies that carry parasites that cause serious illness in humans and domesticated animals. About 22 species make up the genus *Glossina,* family Glossinidae. Tsetse flies are about 0.6 to 1.2 cm (0.25 to 0.5 in) long and usually hold the wings flat against the body. They vary from light yellow brown to dark brown, some with black abdominal bands. Adults depend on blood for survival and are equipped with piercing mouthparts with which they bite and suck blood from their victims. As they suck they

Tsetse flies are African insects that transmit deadly sleeping sickness to humans and the pernicious disease nagana to cattle. An adult fly sucks blood from a human arm (A; before and after feeding). *Trypanosomes* (1), *parasitic flagellate protozoans, injected into the blood cause sleeping sickness. The female tsetse fly hatches her eggs internally and lays living larvae on soil near water* (B). *The larvae burrow into the soil within an hour and become pupae. In 4 weeks the pupa* (C) *becomes an adult.*



transmit parasites of the genus *Trypanosoma* (see TRYPANOSOMIASIS), some of which cause African sleeping sickness in humans and others of which cause nagana, an animal disease. Full-grown larvae, born singly at intervals of about 10 to 15 days, are deposited in mangrove roots and in the shade of other vegetation where soils are moist and loose.

Tshombe, Moise Kapenda [chohm'-bay, moh-ees' kuh-pen'-dah] The Congolese politician Moise Kapenda Tshombe, b. Nov. 19, 1919, d. June 28, 1969, led the province of Katanga (now SHABA) in its period (1960–63) of secession from the newly independent Republic of the Congo (now Zaire). Tshombe became president of the Rassemblement Katangais (CONAKAT), a party supported mainly by the Lunda tribe, in 1959. At the Belgo-African Conference held (1960) to prepare the Belgian Congo for independence, Tshombe called for a loose federation of provinces, closely tied to Belgium. When the Congo achieved its independence that year as a centralized republic, Tshombe was elected provincial president of Katanga. Shortly afterward he declared Katanga to be independent, but the insurgent province, rich in copper and other resources, was crushed by the central government with the aid of United Nations troops. In 1963, Tshombe agreed to give up his secessionist plans and fled to Spain. In 1964, President Joseph KASAVUBU of the Congo asked him to form a government, but in 1965, Tshombe was dismissed from the premiership. He died while under house arrest in Algeria.

Tsimshian [tsim'-shee-uhn] Tsimshian, a North American Indian tribe of the Northwest Coast area, traditionally included a loose confederacy of nine tribes, with salmon-fishing and berrying grounds on the lower Skeena River and winter villages along Metlakatla Pass west of modern Prince Rupert. Two more Tsimshian tribes had villages just below the Skeena canyon, and three more lived on Douglas Channel and on Porcher and Swindle islands. The term also refers to the language that was spoken by the Gitksan and Niska.

Each tribe had four divisions, one for each major matrilineal kin group. All were salmon fishers. The nine Coast tribes and the Niska held exclusive rights to fishing grounds at the mouth of the Nass River. Oil rendered from fish harvested in enormous quantities was an important food and a valuable barter item. The Tsimshian traded it to the HAIDA for huge canoes, carved boxes, and dried halibut, and to the TLINGIT for plaques of copper and mountain-goat-wool robes.

The Tsimshian, Gitksan, and Niska carvers of memorial poles, masks, and elegant raven rattles were often hired by chiefs of other groups. Within each tribe each matriclan had its chief, who inherited the position from his mother's eldest brother. Chiefs gave POTLATCHES to commemorate predecessors and honor heirs. Many chiefs held rights to ceremonies of KWAKIUTL origin.

After 1834 the nine confederated tribes built winter houses near the Hudson's Bay Company's Fort (now Port) Simpson. The missionary William Duncan worked among the Tsimshian beginning in 1857. Eventually he moved his converts to build a model community at Metlakatla, where they adopted white lifeways and abandoned their Indian past. Duncan later quarreled with his bishop and moved with most of his congregation to Alaska, where the U.S. Congress gave them the right to settle on Annette Island at "New Metlakatla." Today the Tsimshian number about 12,000 and live on reservations in British Columbia and Alaska.

Tsinan see JINAN

Tsinghai see QINGHAI

Tsingtao see QINGDAO

Tsiolkovsky, Konstantin [tsee-ohl-kahv'-skee] Konstantin Eduardovich Tsiolkovsky (also Ziolkowsky), b. Sept. 17 (N.S.), 1857, d. Sept. 19, 1935, was a visionary Russian theorist and writer on space travel who, decades ahead of his time, forecast many of the features of modern astronautics. Although nearly deaf from a childhood bout with scarlet fever, Tsiolkovsky educated himself and became a high school teacher of mathematics. Among his articles, which attracted little notice outside Russia, was "Research into Interplanetary Space by Means of Rocket Power" (1903); it described the motion of a rocket in vacuum and weightlessness. He also wrote science-fiction accounts of space adventures in which he accurately described artificial satellites, spacesuits, space colonies, and asteroid mining. These books include *On the Moon* (1895), *Dreams of the Earth and Sky* (1895), and *Beyond the Earth* (1920).

Tso Tsung-t'ang see ZUO ZONGTANG

tsunami [tsoo-nah'-mee] Tsunamis, or seismic sea waves, potentially the most catastrophic of all ocean waves, are generated by tectonic displacements—for example, volcanism, landslides, or earthquakes—of the seafloor, which in turn cause a sudden displacement of the water above and the formation of a small group of WATER WAVES having wavelengths equal to the water depth (up to several thousand meters) at the point of origin. These waves can travel radially outward for thousands of kilometers while retaining substantial energy. Their speed is generally about 500 km/h (300 mph), and their periods range from 5 to 60 minutes. In the open ocean their amplitude is usually less than 1 m (3.3 ft); thus tsunamis often go unnoticed by ships at sea. In very shallow water, however, they undergo the same type of increase in amplitude as swell approaching a beach. The resultant waves can be devastating to coastal areas; the 37-m (120-ft) waves from the 1883 Krakatoa eruption, for example, killed 36,000 people.

Tsunami-producing earthquakes usually exceed 6.5

on the Richter scale, and most tsumanis occur in the Pacific Ocean because of the seismic activity of the Ring of Fire. A tsunami warning system for the Pacific Ocean has been established; it consists of strategically placed seismic stations and a communications network.

Tsushima, Battle of see Russo-Japanese War

Tswana [tswah'-nuh] The Tswana (also known as Bechuana or Botswana) are a Bantu-speaking people of the Sotho group of southern Africa. Of an estimated population of 3,000,000 in the 1980s, about one-third (976,000) were living in Botswana (formerly the Bechuanaland Protectorate) and the remainder in the Republic of South Africa. The Tswana comprise a number of separate tribal groupings, each of which, according to oral tradition, is descended from a common ancestral stock. Although the Tswana traditionally are a cattle-keeping people, subsistence farming of maize and sorghum is an important component of their economy. Traditional economic practices have been seriously disrupted by the periodic migration of large numbers of Tswana men to work as wage laborers in the industrial and mining centers of South Africa.

Important aspects of Tswana society are an elaborate system of stratification based on wealth and a clearcut dichotomy between the nobility (descendants of ruling lineages) and the rest of the population, which is divided into commoners, foreigners, hereditary household servants, and serfs, the latter consisting of the San (Bushmen). Politically, every category with the exception of servants and serfs is represented through a network of district headmen and their local councils.

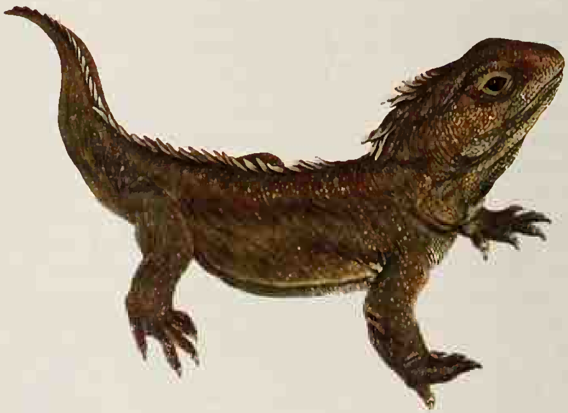
Tu Fu see Du Fu

Tuareg [twah'-reg] The Tuareg, the most celebrated of the tribal populations of the Sahara Desert in Africa, for centuries controlled the valuable trans-Saharan caravan trade in slaves, gold, and ivory. They speak a Berber language and have a rich oral literature. They also have their own alphabet, which is descended from ancient Phoenician script. Their population of several hundred thousand is divided into federations occupying isolated mountains and high country. Tuareg society is highly stratified, with as many as half of the people being serfs and slaves. The noble classes are all nomadic pastoralists. Patron-client relationships bridge the classes, and each federation is ruled by a chief, hereditary through the female line. In religion the Tuareg are Muslims. Unlike other Muslims, however, not only do they reckon descent matrilineally for certain purposes, as in the succession of chiefs, but also the women enjoy considerable freedom. Tuareg men, not women, wear a veil. Although this practice probably originated to protect men against sun, wind, and sand in their desert exposure, it has been highly ritualized, and the veil is seldom removed, even in camp.

The Tuareg are now divided politically under the various jurisdictions of Algeria, Tunisia, Mali, Libya, and Burkina Faso. The closing of national boundaries from about 1960, as these countries became independent, reduced the pastoralists' mobility, resulting in severe hardship from the long droughts of 1968–74 and the 1980s and extensive starvation.

tuatara [too-uh-tar'-uh] The tuatara is a lizardlike reptile found only on a few small islands off New Zealand. It is the only living member of an otherwise extinct reptile order, the Rhynochodephalia, that flourished in the Triassic and Jurassic periods, about 225 million years ago. Only one species, *Sphenodon punctatus*, was recognized for many years, but studies of the reptile's blood led to the 1990 determination of a genetically distinct species, *S. quntheri*, now on the verge of extinction.

Tuataras are about 50 to 80 cm (20 to 31 in) long and have loose, scaly, drab brownish-green skin and a crest of spines along the back and tail. They are distinguished from lizards by an extra arch in the skull, by a firmly anchored quadrate bone, and by the lack of a copulatory organ in the male. Nocturnal and more active at lower temperatures than are other reptiles, they emerge from their burrow homes, often shared with petrels, to feed on insects and other small animals. The eggs require 13 months to hatch.



Tuatara is a rare "living fossil" now restricted to government-protected habitats on islands off New Zealand.

tuba Tuba refers to a family of lip-vibrated, upright, valved, metal wind instruments with a folded tube of wide, conical bore. It was designed to fill an urgent need in brass bands for a satisfactory bass to the valved bugle.

In 1835, Berlin instrument maker Johann Gottfried Moritz, working with bandmaster Wilhelm Wieprecht, patented the first bass tuba, completely distinct from the valved ophicleide, for use in German bands. In 1845, Adolfe Sax, working in Paris, patented a homogenous family of tubas under the name Sax-horn; these were sub-

The orchestral tuba is the double bass of the brass section of the orchestra. It is often used to play quick staccato solos but can also play sustained melodies. The tuba used in military bands may have a fiberglass bell to lessen its weight when carried in marches.

sequently adopted by French bands. Sax and other makers patented slightly different models under other names; the result was a confusing array of tuba instruments in all sizes. Among them the Viennese helicon bass (1849), with its circular coil formed to rest on the player's shoulder, provided an appropriate bass for the marching band and inspired the American sousaphone (1898). Also noteworthy are the 9-foot and 12-foot Wagner tubas in B-flat and F respectively; made with left-hand valves and a relatively narrow bore and played with deep conical mouthpieces by French hornists, these instruments provide a new color midway between the mellow horn and the more aggressive tuba. Since the composition of Wagner's *Ring*, these instruments have been used in other large orchestral scores.

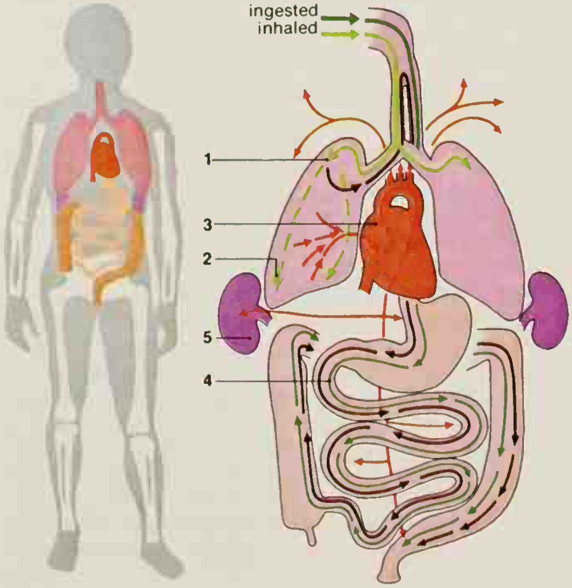
Tuba is also the Roman name for the Etruscan-Grecian *salpinx*, a straight, wide-bored, conical, usually bronze trumpet.

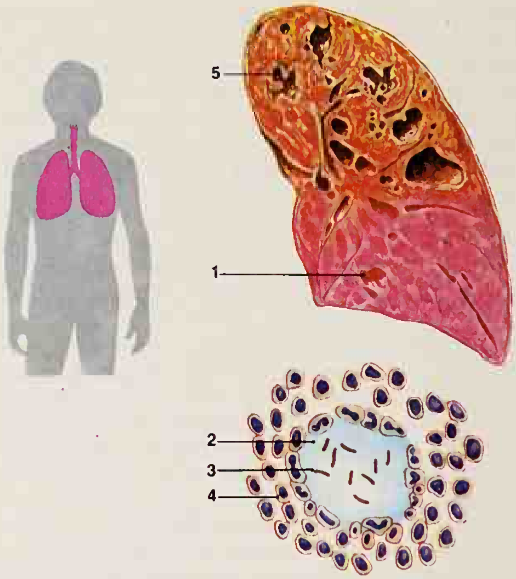
tuber *Tuber* is a Latin term for a lump or swelling and refers to the bulky terminal portion of an underground stem or rhizome of a plant with modified nodes, buds, and leaves. The functions of tubers are food storage and vegetative reproduction; the most commonly stored food is starch. Under natural conditions the attached thin part of the stem or rhizome dies in the autumn or winter, whereas the remaining tuber is able to produce shoots from its buds the following growing season. The best-known example of a tuber is the potato.

tuberculosis An acute or chronic infectious disease of humans and various animals, tuberculosis is caused by bacteria of the genus *Mycobacterium*, often called tubercle bacilli. One of the oldest diseases, it was known as consumption or the great white plague. Human infection with *M. tuberculosis* was one of the leading causes of death until antituberculous drugs were introduced in the 1940s. The bacillus infects the lungs by inhalation of infected droplets formed during coughing of an individual with the active form of the disease. In the vast majority of cases the infection is localized and symptomless, but it may progress to cause chronic pulmonary tuberculosis (active form). The infection can be detected in those who do not develop the disease through a positive tuberculin skin test consisting of a skin injection of a purified protein derived from the bacillus; swelling at the site indicates the presence of infection. The bacilli can remain dormant for years before becoming active. Their widespread presence helps to account for the observed and most likely AIDS-related resurgence of tuberculosis in the United States in the mid-1980s.

Typical symptoms include fatigue, loss of weight and appetite, night sweats and fever, and persistent cough. Sputum is often streaked with blood; sometimes massive hemorrhages occur as the lung tissue is destroyed by the disease. Fluid may collect in the pleural cavity. Gradual deterioration occurs and, if the disease is untreated, death is common. Tuberculosis may spread from the lungs to any part of the body. Other forms include tuber-

Tuberculosis, a contagious disease caused by tubercle bacilli, genus Mycobacterium, *is most often contracted by inhalation but can also result from ingesting unpasteurized milk. In most active cases the bacteria produce lesions, known as tubercles, in the lungs* (1). *Occasionally, the bacteria infect the lymph nodes* (2) *that drain the lungs, enter the bloodstream* (3), *and spread to such organs as the kidneys* (5), *bones and joints, brain, or genital organs. Ingested tubercle bacteria may infect the throat or the intestines* (4).





Infection of the lungs accounts for perhaps 90 percent of all tuberculosis cases. Inhaled bacteria enter the lungs and cause inflammation in small areas called primary foci (1). *These enlarge and form tubercles, which consist of a center* (2) *of cells that have been destroyed by bacteria* (3), *plus a surrounding ring of phagocytic, or bacteria-engulfing, cells* (4). *Usually, the tubercles heal and leave small scars, but in some serious cases the tubercles grow and large cavities* (5) *result from the detachment of lung tissue.*

culous meningitis and miliary tuberculosis, a rapidly fatal form causing disease in many organs.

Tuberculosis may also be acquired from animals, as by drinking their unpasteurized milk. The BCG (Bacille Calmette-Guérin) vaccine, prepared from a weakened strain of live bacilli, confers some protection against tuberculosis.

tuberose [toob'-rohz] Tuberose is the common name for *Polianthes tuberosa*, a perennial garden plant of the family Agavaceae. It is native to southwestern North America but is known only from cultivation. Tuberose plants have tuberous roots and bear clusters of fragrant, waxy, white flowers, which are used in perfumes.

Tubman, Harriet Harriet Tubman, b. Dorchester County, Md., *c.*1821, d. Mar. 10, 1913, was a fugitive slave and abolitionist who became a legendary figure of the Underground Railroad. Born to slave parents, she escaped (*c.*1849) to freedom by following the North Star. Throughout the 1850s she made repeated journeys into slave territory, leading about 300 other fugitives, including her parents, to freedom. Maintaining martial discipline on flights north, Tubman often forced panicky or exhausted "passengers" ahead by threatening them with a loaded pistol. She was aided by Quakers and other abolitionists, and John Brown sought her counsel for the Harpers Ferry raid in 1859. When the Civil War began she served as an army cook and nurse and became a spy and guide for Union forays into Maryland and Virginia. After the war she managed a home in Auburn, N.Y., for indigent and elderly blacks until her death; she was buried with full military honors.

Harriet Tubman, who escaped from slavery in Maryland c.1849, returned repeatedly to the South to lead about 300 other fugitive slaves to freedom. Tubman continued her dangerous exploits during the Civil War, serving as a Union spy and scout. She was known as "the Moses of her people."

Tubman, William V. S. William Vacanarat Shadrach Tubman, b. Nov. 29, 1895, d. July 23, 1971, was president of Liberia from 1944 to 1971. A descendant of African-American settlers, he studied to be a lay Methodist preacher and entered public service. During the 1920s and '30s, after taking a law degree, he served in the Liberian Senate, where he championed the cause of the tribes of the interior against the established oligarchy. He was appointed to the Supreme Court in 1937 and served as Liberia's president from 1944 until his death. Tubman encouraged foreign investment, granted the franchise to women, and expanded revenues, public services, and the army. He insisted that customary tribal laws be maintained insofar as they were "humane and reasonable" but also tried to encourage the immigration of Westernized blacks.

Tucker, Richard Richard Tucker, b. New York City, Aug. 28, 1914, d. Jan. 8, 1975, was one of the greatest operatic tenors of his generation. In early childhood he attracted attention with his liturgical singing in synagogue but received no operatic training until he was in his mid-20s. He made his debut (1945) at the Metropolitan Opera as Enzo in Ponchielli's *La Gioconda* and remained with the company for his entire 30-year career, specializing in the Italian repertory.

Tucson [too'-sahn] Tucson, the second largest city in Arizona, is located about 110 km (68 mi) north of Mexico.

The seat of Pima County, Tucson has a population of 405,390 (1990), and metropolitan Pima County, 666,880. In a valley surrounded by the Santa Catalina Mountains, the city is a distribution center for vegetables, citrus fruits, cotton, livestock, and dairy products. Copper mining is important. Tucson produces guided missiles, electronic equipment, steel, paints, soap, and clothing. Because of its warm, dry climate, it is a tourist and resort center. Tucson has historical museums and a symphony orchestra; located nearby are Saguaro National Monument, Coronado National Forest, and Tucson Mountain Park. The University of Arizona (1885) is located in Tucson.

An Indian settlement, Stjukshon, occupied the site when the Jesuit Eusebio Kino arrived in the late 17th century and established the mission of San Xavier del Bac. By 1776 a Spanish army post was there. The area passed to the United States in the Gadsden Purchase (1853), and from 1867 to 1877, Tucson was the capital of Arizona Territory. The arrival of the Southern Pacific Railroad in 1880 and discovery of nearby silver and copper deposits assured its prosperity.

Tucumán [too-koo-mahn'] Tucumán, or San Miguel de Tucumán (1980 pop., 498,579), is a city and provincial capital located in northwestern Argentina. Sugar refining is the major industry, but tourism and the processing of grain, meat, and milk are also important. Founded (1565) by Diego de Villaroel, a Spanish conquistador, Tucumán was relocated to its present site in 1668 after frequent Indian raids. Argentina's declaration of independence and first constitution were written at the Congress of Tucumán (1816–20). The introduction of sugarcane cultivation in the early 19th century spurred Tucumán's growth.

Tudor (dynasty) The Tudors, a family of Welsh origin, ruled England from 1485 to 1603. The first family member of note was **Owen Tudor**, *c.*1400–1461, who married (*c.*1429) Catherine of Valois, the widow of the Lancastrian king Henry V. Owen fought on the Lancastrian side during the Wars of the Roses (1455–85; see ROSES, WARS OF THE). His eldest son, **Edmund Tudor**, *c.*1430–1456, married Margaret Beaufort (see BEAUFORT family), a descendant of King Edward III. Edmund's posthumous son became the first Tudor monarch as HENRY VII, winning the throne when he defeated (1485) the Yorkist king Richard III at Bosworth Field and thereby ended the Wars of the Roses. Henry VII's son succeeded him as HENRY VIII and was succeeded in turn by his children, EDWARD VI, MARY I, and ELIZABETH I. Queen Elizabeth had no direct heirs; thus on her death (1603) the throne passed to James VI, king of Scotland, a descendant of **Margaret Tudor**, 1489–1541, daughter of Henry VII. As James I, he was the first of the Stuart family to rule England. Although the reign of the Tudors was a period of great religious strife, the English monarchy consolidated its power, English nationalism and naval strength grew, and literature and scholarship flourished.

Tudor, Antony Antony Tudor (William Cook), b. London, Apr. 4, 1908, d. Apr. 19, 1987, was a British choreographer who first explored the depths of human psychology in ballet. For Marie Rambert's company he made such masterpieces as *Jardin aux lilas* (Lilac Garden; 1936) and *Dark Elegies* (1937). With others, he formed the London Ballet in 1938, but during World War II it was absorbed into Ballet Rambert.

For the newly founded (American) Ballet Theatre (ABT) in New York City Tudor revived some of the works he had made in Britain, and in 1942 he choreographed *Pillar of Fire*, which made the reputation of both Tudor and Nora Kaye, who created the leading role of a repressed spinster. This work was followed by *Dim Lustre* (1943), *Romeo and Juliet* (1943), and *Undertow* (1945).

In 1950, Tudor left ABT to head the Metropolitan Opera Ballet School and briefly worked with the Royal Swedish Ballet and New York City Ballet, but for many years he produced no major work. In 1967, however, he was invited by Sir Frederick Ashton to choreograph *Shadowplay* for the Royal Ballet. In 1974 he rejoined ABT as associate director and choreographed *The Leaves Are Fading* (1975) and *The Tiller in the Fields* (1979). He became choreographer emeritus of ABT in 1980.

Tudor style The term *Tudor style* describes the forms of English architecture during the reign of the first Tudors, Henry VII and Henry VIII—that is, from about 1480 to about 1540. It is, in essence, a Gothic architecture that retains asymmetrical plans, pointed windows, and ribbed vaulting; this is clear in such buildings as Magdalen College, Oxford (1474–90), and the chapel of Henry VII, Westminster Abbey (1503–19). The latter is the masterpiece of the English Perpendicular Gothic style, a form characterized by a very rich and detailed yet orderly articulation of forms. In time, especially after 1500, the Tudor style began to reflect European influences. In the most general terms, plans became more symmetrical and designs were increasingly seen in terms of small, individual units rather than the linear patterning that is so marked in the English Gothic. More specifically, new forms came into use and more and more exotic detailing, often carried out by European artisans, was introduced, including simple octagonal towers, polychrome brick, niches, plaques, decorated chimneys, and—inside the buildings—the most elaborate fireplaces. Such detailing and planning changed the character of this architecture without altering its fundamental form; this is seen, for example, in the still predominantly Gothic form of such buildings as the Tower, Eton College (1515), and the Quadrangle, Christ Church, Oxford (1525–29). These forms could only be succeeded by a fundamentally different architecture, which was to become known as the ELIZABETHAN STYLE.

tufa see SINTER

Tufts University Established in 1852, Tufts University is a private coeducational institution in Medford, Mass. Tufts includes schools of dentistry, medicine, and veterinary medicine and the Fletcher School of Law and Diplomacy.

tugboat The tugboat is a small, powerful craft used to move BARGES, to berth large oceangoing SHIPS, and to tow disabled vessels. Paddle-wheel–propelled tugboats made their appearance around 1800 with the beginning of the age of steam. Screws replaced paddle wheels about 1850, and by 1900 diesel engines had supplanted steam. In the past century the size of tugs has remained fairly constant, ranging from 21 to 64 m (70 to 210 ft), but their engines are now much more powerful. Berthing tugs have resilient wooden hulls that prevent damage to both ship and tug during the docking operation. On inland waterways tugs are used with dumb (nonpowered) barges. In the United States tugs usually push a line of barges, whereas in Europe they pull the barges by a towline. A single tugboat may power 10 to 20 barges.

Tugwell, Rexford G. Rexford Guy Tugwell, b. Sinclairville, N.Y., July 10, 1891, d. July 21, 1979, was an American economist, political scientist, and public official. In 1932 he joined Franklin D. Roosevelt's campaign staff as part of what came to be called the Brain Trust, a group of leading political and social thinkers recruited to advise the president-to-be. During Roosevelt's first two terms, Tugwell headed the Rural Resettlement Administration, where he worked on moving farmers to more productive land. An active voice in U.S. politics for nearly 60 years, he later served as governor of Puerto Rico (1941–46) and director of the University of Chicago's Institute of Planning (1946–52).

Tuileries [twee'-lur-eez] The name *Tuileries* designates both the gardens in Paris lying along the right bank of the Seine from the Palace of the LOUVRE to the Place de la Concorde and the palace formerly situated there. The word is derived from the tile factories, or *tuileries*, that were established there in the 13th century. Although modified, the garden still follows the overall plan (1664) of André Le Nôtre. The Palace of the Tuileries was begun in 1564 for Catherine de Médicis by the architect Philibert DELORME; it was occupied only intermittently by French royalty until Louis XVI and his family were compelled to reside there during the French Revolution. Thereafter, several of France's rulers made it their personal headquarters. After 1792 the palace became the target of popular uprisings and in 1871 was burned during the Commune of Paris.

Tula [too'-luh] Tula was the capital city from which the TOLTECS dominated much of MESOAMERICA from the 10th through 12th centuries AD. It is located about 60 km (37 mi) northwest of present-day Mexico City, farther north than any prior or subsequent Mesoamerican capital. Tula was the center of a great trading network developed by the Toltecs that reached from the American Southwest to Costa Rica. According to both Central Mexican and Maya annals, the Toltec king QUETZALCÓATL fled Tula and went to CHICHÉN ITZÁ, in southeastern Mexico, in 987, where he was known as Kukulcán, or Feathered Serpent. During this era, and perhaps for several generations before, similar art and architecture appeared at both Tula and Chichén Itzá.

Although generations of scholars assumed from this story that Tula had conquered Chichén Itzá, many scholars now question that assumption and believe that the similarities may have resulted from trade and exchange rather than conquest. New forms of art and architecture, including columns and colonnades, caryatids, atlantean (Atlas-like) figures, serpent columns, and reclining captives called *chacmools*, may have been used first at Chichén and then adopted at Tula.

At Tula, Mexican archaeologists have excavated and restored the great temples and adjacent buildings. The Burned Palace, contiguous with Pyramid B, has been determined to be the center of Toltec administration.

Tulane University [too-layn'] Established in 1834, Tulane University is a private coeducational institution in New Orleans, La. It has schools of architecture, business, engineering, law, medicine, public health and tropical medicine, and social work. Newcomb College (1886), formerly its college for women, is now its college of arts and sciences.

tularemia [too-luh-ree'-mee-uh] An acute, infectious disease to humans, tularemia, or "rabbit fever," occurs mainly in rodents and wild rabbits. Caused by a bacterium (*Francisella tularensis*), the disease is named for Tulare County, Calif., where it was first identified in 1911. Humans can contract tularemia through direct contact with infected animals, or indirectly from bites by infected ticks or deerflies, the primary transmitters. Following a 2- to 10-day incubation period, symptoms develop that include an ulcer at the site of entry, swollen lymph nodes, and intermittent high fever and headaches for several weeks. The disease can be fatal if diagnosis is delayed. Streptomycin and tetracycline are effective therapies.

tulip Tulip is the common name for between 50 and 150 species of the genus *Tulipa* in the lily family, Liliaceae. These prize garden flowers, native to Asia, historically have been associated with one major producer, the Netherlands, although they are now grown throughout the temperate regions of the world. Tulips are hardy perennial

The tulip has been a favorite garden and greenhouse flower for centuries. The breeder tulip (left) *is the most familiar variety. Two other types are the small, wild tulip* (center) *and the parrot tulip* (right), *which is popular for its elaborate petals.*

herbs grown from bulbs, which produce long, broad leaves from the base or stem. Cup-shaped or bell-shaped flowers are borne on a single scape and come in a variety of solitary or variegated colors except blue. Bulbs should be planted in rich, well-drained soils during the fall for flowering the following spring.

tulip tree The tulip tree, or yellow poplar, *Liriodendron tulipifera*, is a deciduous forest tree of the eastern United States and southern Ontario. It is not a poplar, but rather a member of the magnolia family, Magnoliaceae. This tree is used as an ornamental, having showy, tulip-shaped, yellow green flowers with a broad orange band at the base and distinctive four-lobed, notch-tipped leaves. The cone-shaped fruits contain many overlapping winged seeds. Tulip trees are resistant to disease and grow quickly, attaining heights up to 61 m (200 ft), taller than any other eastern forest tree. The light, soft, easily worked wood is commercially valued.

Tull, Jethro Jethro Tull, b. 1674, d. Feb. 21, 1741, was an English agriculturist and inventor who had an important influence on English agricultural methods. Educated in law at Oxford University, Tull inherited his father's farm and began to study farming practices and devise new agricultural systems. Convinced that crops would grow better if planted in rows—with between-row cultivation to keep weeds down—Tull devised the first successful mechanical seed drill as well as a horse-drawn row cultivator. He published *The Horse-hoeing Husbandry, or an Essay on the Principles of Tillage and Vegetation* in 1733.

Tulsa [tuhl'-suh] Tulsa, a city on the Arkansas River in northeastern Oklahoma, is the seat of Tulsa County and the financial and commercial center of a major oil-producing region. The state's second largest city, Tulsa has a population of 367,302 (1990), with 708,954 persons in the metropolitan area.

Hundreds of petroleum concerns maintain plants and offices in Tulsa. The aviation-aerospace industry, wholesale distribution, mining, metal processing, and manufacture of machinery contribute to the city's economy. With major airlines, trucklines, and railroads, as well as barge traffic along the McClellan-Kerr Waterway, Tulsa is a transportation center. The University of Tulsa (1894) and Oral Roberts University (1963) are there.

Settlement in the Tulsa area began in 1836, when Creek Indians moved there from Alabama. Arrival of the St. Louis–San Francisco Railway in 1882 brought settlers, and the town's principal industry became cattle shipping. The city's phenomenal economic and population growth began in 1901 with the discovery of vast petroleum deposits nearby.

tumbleweed The name tumbleweed applies to several plants that are dislodged and rolled along by the wind when mature or dead. The most common in western North America is the Russian thistle, *Salsola kali*, family Chenopodiaceae; it has reddish, spine-tipped leaves and small flowers. Others include *Amaranthus albus*, family Amaranthaceae, and *Sisymbriamum altiassiamum*, family Cruciferae.

tumor A tumor is a mass of new tissue growth (neoplasm) that is unresponsive to normal controls or the organizing influence of adjacent tissues; it has no useful physiological function. This definition applies to both malignant and benign tumors. Malignant, or cancerous, tumors, however, are additionally defined by their invasion of local tissue and their ability to spread, or metastasize, in other parts of the body (see CANCER).

A benign tumor generally grows slowly and kills the host only if it interferes in some way with a critical function. It is usually encapsulated within a membrane. The cells of benign tumors closely resemble the cells of the tissue of origin. Superficial benign tumors include warts and moles.

A malignant tumor always kills (unless treated) because of its invasive and metastatic characteristics. Solid tumors, which develop in the breast, colon, lung, and other organs, contain an inner core with high-pressure zones that compress and collapse blood vessels, often preventing the penetration of blood-borne cancer treatments. A tumor grows locally by invading surrounding normal tissues. It spreads to distant sites by the breaking off of malignant cells, which move through the blood and lymph, attach themselves, and begin to grow as new colonies. In general, if the tumor is derived from epithelial tissue, it is a carcinoma; if it arises from connective tissue, it is a sarcoma.

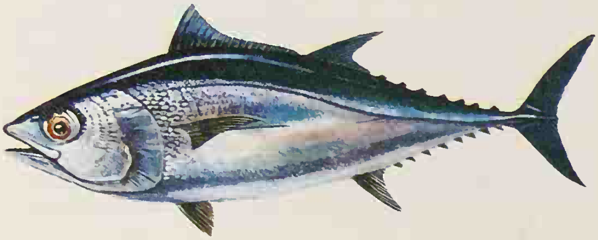
The factors controlling tumor growth are poorly understood, although the genetic apparatus of a cancer cell seems to play a role. Tumors in laboratory animals may be transplanted to a second host using only a single tumor cell. This suggests that only one normal cell need become transformed (cancerous) for tumor growth to begin. Tumors have been experimentally induced in animals by chemical, physical, and viral agents, and by radiation and chronic irritation.

Cancer researchers no longer believe that a single drug will be able to cure cancer. Experts now believe that a combination of drugs will be the best method to kill tumors. One route being researched uses antibodies that bind to specific receptors on the tumor cell, thus inhibiting tumor growth by blocking certain tumor-growth factors from entering the cell. Tumor necrosis factor (TNF), an immune-system protein, is effective in cutting off the blood supply to tumors, although too much TNF causes severe side effects.

Tun-huang see DUNHUANG

tuna Tunas are among the largest, most specialized, and most commercially important of all fishes. Seven species, making up the genus *Thunnus* of the tuna-and-mackerel family, Scombridae, are found in temperate and tropical oceans around the world and account for a major proportion of the U.S. fish catch and U.S. fish imports.

Tunas typically have cigar-shaped, streamlined bodies with two dorsal fins—the first spiny, the second soft-rayed and followed by finlets—a narrow tail region, and a large, deeply forked tail. They vary extensively in size, color, and fin length. Along with the mackerel sharks, tunas are unique among fishes in having a body temperature higher than that of the surrounding water—a result of a complex circulatory system and continuous sustained activity. Fast swimmers, traveling at more than 48 km/h (30 mph), they typically migrate long distances and appear only seasonally in any one location. Tunas occur both in surface waters and at great depths, where their large eyes help them to see in the dark. They feed on other fish and on squid.



The bluefin tuna, found worldwide, mostly in temperate and subtropical waters, is an important food fish.

The largest species, a highly prized sport fish, is the bluefin, *T. thynnus*, found worldwide. Some specimens exceed 4.2 m (14 ft) and weigh more than 680 kg (1,500 lb). Other important species include the albacore, *T. alalunga*, a small fish, often less than 18 kg (40 lb), which is famed for its tasty white meat; the large yellowfin, *T. albacares*; and the deep-water bigeye, *T. obesus*.

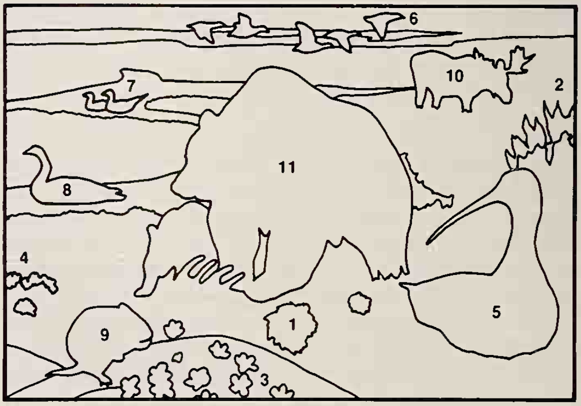
The tuna fishery is controlled by international agreements limiting how much fishers may take and where they may fish—limits that are not always observed. Another major problem is created by the method used to harvest tuna: huge nets are stretched across kilometers of ocean, capturing sea birds, seals, porpoises, and dolphins along with the tuna.

tundra [tuhn'-druh] Derived from a Finnish word for "barren land," the term *tundra* refers to the treeless area circling the North Pole. Similar conditions found at high elevations on mountain slopes in middle and low latitudes are called Alpine tundra.

The equatorward limits of the tundra coincide approximately with the warmest isotherm of 10° C (50° F), which in the Northern Hemisphere marks a boundary between the tundra and the TAIGA CLIMATE.

The tundra is characterized by lakes, bogs, and streams. Vegetation consists of mosses, lichens, grasses,

(Facing page) *During the short tundra summers, water from melted snow collects above the permafrost to form marshy areas. Although most plants reproduce by asexual means, many flower during the brief growing season. North American tundra vegetation includes cotton grass* (1), *a perennial sedge with cottony flower clusters; fireweed* (2), *a common herb; saxifrage* (3), *found on rock outcrops; and forget-me-not* (4), *which bears small, showy flowers. Lichens and mosses are also common. Many birds nest on the tundra during summer; most, including the four species shown, migrate south to avoid the harsh winter. The whimbrel, or Hudsonian curlew* (5), *nests in a grass-lined depression in the ground. Common eider ducks* (6; males shown) *nest along the seacoast. The pintail duck* (7) *and Canada goose* (8) *have wide breeding ranges in North America. Most land mammals do not migrate. Meadow voles* (9) *winter in runways between the snow and ground, where they feed on vegetation. Moose* (10) *and brown bear* (11; shown with cub), *which usually inhabit northern forests, sometimes venture onto the tundra.*



and dwarf shrubs. The regrowth of vegetation is slow, and severe erosion can cause scarring of the landscape. The tundra differs from the polar region and the evergreen forest belt by two features: alternate freezing and thawing of the topsoil and continuous permafrost.

Although few in number, tundra animals sometimes achieve large populations, as, for example, the lemmings. Some animals remain in the tundra (musk ox and polar bear), whereas others range to the taiga (ptarmigan, caribou, and snowy owl). The sizable numbers of birds include ducks, geese, and plovers.

Tundra winters are long and cold, whereas summers are short and cool. Average annual temperatures are generally below 0° C (32° F), and the annual range is large except in areas that are favored by ice-free waters offshore. Barrow, Alaska, has a February average of –28° C (–18° F) and a July average of 4° C (39° F). Western tundra coasts of Alaska and Europe experience more moderate temperatures due to maritime influences. Low sun angle and sea ice cause low temperatures even during the long days of summer. Frost may occur in any month.

The low temperatures and poor drainage characteristic of the Arctic tundra result in boggy acidic soils and lead to the accumulation of organic debris. The lower part of the soil profile typically becomes waterlogged and has a clay soil horizon underlain by permafrost. Annual precipitation is less than 350 mm (14 in) over most of the tundra; the precipitation falls mainly during the warmer half of the year.

tuner see RADIO; RECEIVER (communications)

Tung Ch'i-ch'ang see DONG QICHANG

tungsten [tuhng'-stuhn] Tungsten is a heavy metallic element, a member of the third series of transition metals and of Group VIB of the PERIODIC TABLE. It has the symbol W, its atomic number is 74, and its atomic weight is 183.85. The name is derived from the Swedish *tung sten*, meaning "heavy stone." Tungsten is also known as wolfram, from wolframite, the mineral from which the element was first recognized by Peter Woulfe in 1779. The de Elhuyar brothers first isolated the metal in 1783 by the charcoal reduction of an acid in wolframite.

Tungsten occurs principally in the minerals scheelite ($CaWO_4$), wolframite ($[Fe,Mn]WO_4$), huebnerite ($MnWO_4$), and ferberite ($FeWO_4$), which are found in California, North Carolina, South Korea, Bolivia, the USSR, and Portugal. The metal is obtained commercially by the reduction of tungstic oxide with hydrogen or carbon. Pure tungsten is steel gray to tin white in color. Its physical proper-

ties include the highest melting point of all metals, 3,410° C, a boiling point of 5,660° C, and a density of 19.3 g/cm^3. It displays a range of oxidation states from +1 to +6 and forms many complex ions.

Pure tungsten is easily forged, spun, drawn, and extruded, whereas the impure metal is brittle and can be fabricated only with difficulty. Tungsten oxidizes in air, especially at higher temperatures, but is resistant to corrosion and is only slightly attacked by most mineral acids.

Because heat causes tungsten to expand at about the same rate as glass, the metal is widely used to make glass-to-metal seals. Tungsten or its alloys are used for filaments for electric lamps, electron and television tubes, electrical contact points for automobile distributors, heating elements for electrical furnaces, and many space, missile, and high-temperature applications.

Tungsten carbide is an important compound in the metalworking, mining, and petroleum industries. Alloys such as high-speed steel, cristite, and stellite, used in high-speed tools, contain tungsten. Other important tungsten compounds are calcium and magnesium tungstates, which are used in fluorescent lighting, and tungsten disulfide, which is used as a high-temperature lubricant at temperatures up to 500° C. Tungsten compounds also find uses in the chemical, paint, and tanning industries.

Tunguska fireball [tun-goo'-skuh] At sunrise on June 30, 1908, the area near the Tunguska River in Siberia was the site of a tremendous explosion that had the force of a modern H-bomb and took place at an altitude of several kilometers. Although the explosion flattened trees for kilometers in all directions, no crater was formed, and aside from some microscopic nodules extracted from the soil, no recognizable fragments of an extraterrestrial object remain. Space scientists generally believe that the explosion was caused by a small comet that disintegrated in midair; several smaller events of a similar nature have since been observed. Various UFO enthusiasts in the USSR and elsewhere, however, have suggested that the blast was atomic and was created artificially—a fanciful idea that depends in the main on misinterpretation, exaggeration, and falsification of the relevant data, according to many observers.

tunicate [too'-nuh-kayt] Tunicates are solitary or colonial marine animals encased in an often thick covering called a tunic. They are primitive chordates, the larval forms possessing a notochord and nerve cord, and as such are forerunners of the vertebrates. The more than 1,300 species, making up the chordate subphylum Tunicata, or Urochordata, are classified in three classes: the usually sessile sea squirts (Ascidiacea); the free-swimming, cask-shaped chain tunicates and salps (Thaliacea); and the surface-dwelling tadpolelike larvaceans (Larvacea). Adult tunicates, often transparent, range in size from microscopic to a diameter of 30 cm (1 ft) or more. Cilia associated with a perforated pharynx are used for feeding. The life cycle of most forms includes a remarkable metamorphosis from a pelagic larval stage resembling a miniature tadpole to an often nondescript adult that essentially lacks the chordate characteristics.

tuning fork A tuning fork, a slender, pocket-sized metal device consisting of a stem with two prongs, is used to provide a standard for the judging of pitch accuracy in voices and musical instruments. When gently tapped it is set in vibration, producing a pure tone (without overtones) that remains—because it is made of chromium-nickel-steel alloy—virtually the same in all weathers. Tuning forks are usually set at the standard "international A" pitch (440 vibrations per second).

Tunis [too'-nis] Tunis, the capital and largest city of Tunisia, is situated about 10 km (6 mi) inland from the southern shore of the Gulf of Tunis (an inlet of the Mediterranean Sea), on an isthmus separating the shallow Lake of Tunis from the Sedjoumi salt marsh. The lake is connected by canal (built 1893) to the adjacent port of Halq al-Wadi (formerly La Goulette). The city's population is 596,654 (1984). The nucleus of Tunis is the densely populated medina (old city), an oval-shaped district consisting of low white buildings, inner courtyards, and narrow streets clinging to the side of the western hills. The modern city centers on the Avenue Habib Bourguiba.

Tunis is the commerical and industrial center of the country. The main industries are food processing; the manufacture of textiles, carpets, chemicals, and cement; and tourism. The University of Tunis (1960), the Bardo Museum, and the Kouba Museum of Islamic Art are there. Points of interest include Zitouna Mosque (732), remnants of the city's medieval walls, and the Roman aqueduct connecting Zaghouan and CARTHAGE.

Colonized by Phoenicians in the 9th century BC, the city was a dependency of Carthage until that city's destruction in 146 BC. Tunis flourished as part of the Roman Empire, and following the Arab conquest in the 7th century the city served as the seat of several Muslim dynasties. Under the administration of Turkish beys from the late 16th century, Tunis became a center of Barbary Coast piracy (see BARBARY STATES). The city, along with the rest of Tunisia, was brought under French rule in 1881. Following the French withdrawal (1956), the once-large European population greatly declined.

Tunisia [too-nee'-zhuh] The Republic of Tunisia, smallest of the four countries in the North African MAGHRIB, borders Algeria on the west, Libya on the southeast, and the Mediterranean on the east and north. Tunisia became independent in 1956 after more than 70 years as a French protectorate. Tunis is its capital.

Land and Resources

The ATLAS MOUNTAINS extend into northern Tunisia, where they form two chains. The highest peaks are Mount Chambi, which rises to 1,544 m (5,066 ft) near the Alge-

AT A GLANCE

REPUBLIC OF TUNISIA

Land: Area: 163,610 km^2 (63,170 mi^2). Capital and largest city: Tunis (1984 pop., 596,654).

People: Population (1990 est.): 8,095,492. Density: 49.5 persons per km^2 (128.2 per mi^2). Distribution (1985): 53% urban, 47% rural. Official language: Arabic. Major religion: Islam.

Government: Type: republic. Legislature: National Assembly. Political subdivisions: 23 governorates.

Economy: GNP (1989): $10.1 billion; $1,260 per capita. Labor distribution (1989): agriculture—22%; manufacturing—16%; government and services—33%; construction—11%. Foreign trade (1989): imports—$4.4 billion; exports—$3.8 billion. Currency: 1 dinar = 1,000 millimes.

Education and Health: Literacy (1984): 46% of adult population. Universities (1984): 1. Hospital beds (1987): 15,838. Physicians (1987): 3,474. Life expectancy (1990): women—70; men—68. Infant mortality (1990): 40 per 1,000 live births.

rian border, and Mount Mrhila, at 1,378 m (4,521 ft), southwest of Tunis. The Medjerda Valley, which separates the two chains, is a series of basins with rich alluvial soils. Cork-oak and evergreen forests cover the northern mountains.

The steppe plateau of central Tunisia slopes eastward toward the coastal plain of the Sahel, which extends into Libya. The High Steppe, which has an average elevation of 457 m (1,500 ft), is composed of alluvial basins surrounded by low, barren mountains. The Low Steppe, with an average elevation of 183 m (600 ft), is a flat, gravel-covered plateau. The northernmost section of the Sahara Desert lies in the extreme south.

Tunisia has a Mediterranean climate in the north, with mild, rainy winters and hot, dry summers. Winter rainfall ranges from an average 406 mm (16 in) a year in the northeast to less than 152 mm (6 in) in the south. Precipitation is irregular, and prolonged periods of drought are common in central and southern Tunisia. Temperatures along the coast average 7° C (45° F) in January and 32° C (90° F) in August. Daily and annual ranges are greater elsewhere. Southern Tunisia has an arid climate, and hot, dry sirocco winds from the Sahara are common in summer.

Intermittent streams form after heavy rains but eventually fan out as they cross the steppes, and the water evaporates in salt flats, or sebkhas. The only perennial stream in Tunisia is the Medjerda. Two large intermittent salt lakes occupy a vast depression south of the steppes. The larger, Shatt Djerid, lies 16 m (52 ft) below sea level.

Petroleum, calcium phosphates, and iron ore are the most important mineral resources.

People

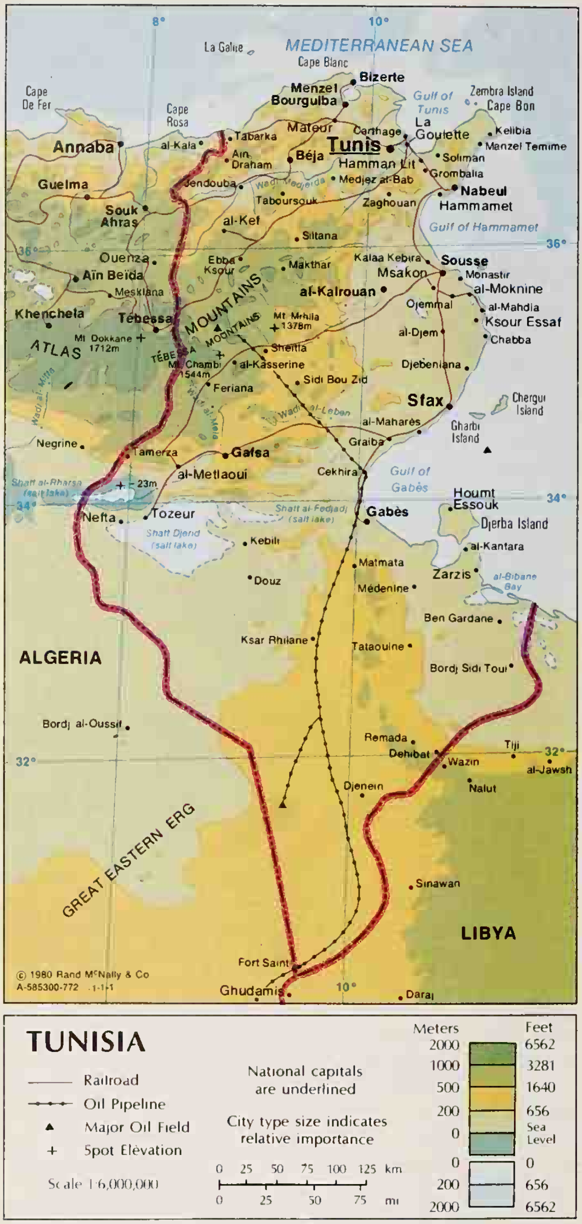
Arabization of the native Berber population proceeded rapidly after the Arab conquest in the 7th century. Large numbers of Spanish Arabs settled in northern Tunisia in the 16th century, and Italian and French colonists arrived there after 1850. The Jewish community in Tunisia was one of the oldest and most important in North Africa, but most of the non-Muslim minorities have now emigrated.

Arabic is the official language and Islam the official religion of Tunisia. However, French remains a dominant language in the press, in education, and in government. Berber-speaking people, who form less than 1% of the population, live in small isolated villages in southern Tunisia.

Tunis and Sfax are the largest cities. The coastal city of Bizerte is a major port. Tunisia has a serious unemployment problem aggravated by a high rate of population growth.

Primary education is mandatory; higher education is pursued primarily at the University of Tunis (1960). Medical care is provided through a social security system to all wage earners.

Tunisian arts are a mixture of the traditional and modern, with strong European influences, especially French. The government has made a major effort to encourage the arts and to diffuse cultural benefits to the entire population.



Economic Activity

The Tunisian nation has worked diligently to gain control of its resources, and the government plays an active role in development planning. The economy is based on agriculture and mining, although the proportion of the labor force engaged in agriculture has steadily declined. Cereals and wheat are the main crops, and citrus fruits, olive oil, dates, and wine are also important. Livestock includes sheep, goats, and cattle; forestry is confined to cork and oak.

The tourist and fishing industries are of increasing importance, and foreign companies have been encouraged to establish factories in Tunisia for the manufacture of export-oriented goods. Manufactured goods include textiles and clothing, paper, steel products, construction materials, household articles, cement, and fertilizers. The iron smelter and petroleum refinery at Bizerte and a chemical complex at Gabès are attempts at large-scale development.

Livestock graze on an arid hillside in Matmata, a village in eastern Tunisia. Although raising livestock is an important economic activity, the nation's most valuable agricultural products are the wheat, olive oil, and fruits grown farther north.

Tunisia's road and rail network centers on Tunis. Crude petroleum accounts for 41% of exports. Textiles account for another 21%, and phosphates and chemicals, 17%. Imports consist chiefly of raw materials, machinery, foodstuffs, and consumer goods. Remittances from workers abroad, long an important source of income, have declined in recent years. The country suffers from a recurrent trade deficit, which is partially covered by tourist receipts and foreign aid.

Government

The 1959 Tunisian constitution vests legislative power in the National Assembly, elected by universal suffrage. The president is the chief executive of the republic; a cabinet, headed by a prime minister, is responsible to him. Judicial independence is constitutionally guaranteed. Habib BOURGUIBA, who ruled Tunisia from 1957 to 1987, was elected president for life in 1975. The Constitutional Democratic Rally (formerly the Destour Socialist party) controls political life, although opposition parties have been legal since 1983.

History

Tunisia was part of the ancient city-state of CARTHAGE, which fell to the Romans in 146 BC. It was an economically important part of the Roman Empire's Africa province.

The Arabs gained control in the 7th century and moved the capital from Carthage to al-Kaiouan. The Arabic language and Islam replaced Latin and Christianity, and the native Berbers supported the new Arab empire. Successive invasions by Bedouins from Arabia, Normans from Sicily, and Moroccans followed. The Ottoman Empire conquered Tunisia in 1574.

As one of the so-called BARBARY STATES, Tunisia became a center of piracy, on which the public treasury depended until about 1817. As the country fell into political and economic chaos, Great Britain, Italy, and France vied for influence. France finally gained a free hand at the 1878 Congress of Berlin and established a protectorate in 1881.

The protectorate lasted until 1956. In 1957 a republic was proclaimed with Habib Bourguiba as its president. Bourguiba subsequently consolidated his political power in Tunisia and strengthened relations with France and the Arab states. Palestinian leader Yasir ARAFAT had his headquarters in Tunis from 1982 to 1986. In 1983, Tunisia signed a cooperation agreement with Algeria and Mauritania. Economic problems sparked antigovernment riots in 1984 and contributed to a rise in Islamic fundamentalism and the seizure of power from the ailing Bourguiba in 1987 by Prime Minister Zine el-Abidine Ben Ali. Ben Ali, who released many political prisoners and liberalized the economy, remained head of state following presidential and legislative elections in 1989. The country remained neutral during the 1991 GULF WAR.

tunnel A tunnel is a primarily horizontal passageway produced by excavation and used for transportation, mining, conducting water and sewerage, or housing underground facilities. Modern tunneling techniques include drilling and blasting, soft-ground tunneling by shield, use of prefabricated tubes, and, most recently, mechanical excavation.

History

Tunnels were built in Paleolithic times in order to extend natural caves. The Babylonians dug tunnels for irrigation, and the ancient Egyptians and Indians dug them for tombs. The ancient Greeks used tunnels for draining marshes and for AQUEDUCTS.

The Romans built tunnels from shafts that also provided ventilation; they also developed (probably from Etruscan origins) the fire-quenching method of hard-rock tunneling, in which rock was heated by fire and suddenly cooled by water thrown against it, causing it to scale or crack. The Roman Pausilippo Tunnel was cut (36 BC) through volcanic rock, to connect Pozzuoli with Naples.

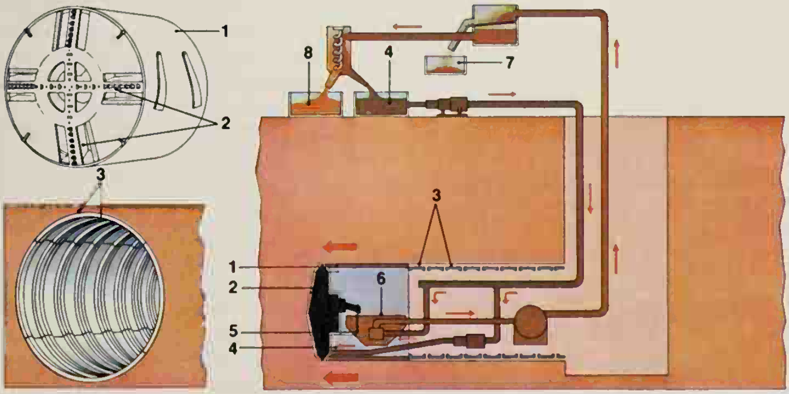
Canal builders enlarged the art of tunneling in the 17th and 18th centuries. Pierre Riquet first used (1666–81) blasting with gunpowder in building the Malpas Tunnel near Béziers for the Languedoc Canal.

The coming of the railroad brought a tremendous demand for tunnels. The first steam-railway tunnel, the Wapping, under Liverpool, was built by George STEPHENSON in 1826–27. Great strides in tunnel technology were made in digging railroad tunnels through mountain rock, beginning with the first Alpine tunnel, the Mont Cenis Tunnel (14 km/8.5 mi long) between Italy and France (1857–71). Although the Mont Cenis Tunnel was begun using manual drilling, engineer Germain Sommeiller later employed many revolutionary techniques, including rail-mounted drill carriages, compressed-air drills, and hydraulic compressors.

At the same time in the United States the 7.2-km (4.5-mi) Hoosac Tunnel was being built (1855–76) through the Berkshires. Important advances included one of the first uses of dynamite and the use of compressed-air drills.

Subsequent major Alpine tunnels included the 15-km (9.3-mi) Saint Gotthard Tunnel (1872–82); the 20-km (12-mi) First Simplon Tunnel (1898–1906), between Italy and Switzerland, for many years the longest transportation tunnel in the world; and the 14-km (9-mi) Lötschberg Tunnel (1906–11).

Paralleling the development of rock tunneling in the 19th century was that of subaqueous tunneling, made possible by the invention of the tunneling shield (a metal shell the size of the tunnel) by engineer Marc Brunel (see BRUNEL family), a French émigré, in London. Brunel's first shield was designed to tunnel under the River Thames



The closed-shield method is used for tunneling through soft clay, gravel, and sand. A steel cylinder, or shield (1), closed at the front end and containing rotating excavation blades (2), is moved forward by hydraulic jacks pushing against the tunnel linings (3). To facilitate excavation, the soft, unstable earth is hardened by mixing it with a bentonite slurry (4) under pressure. The excavated material is removed (5) to a waste vat (6) and pumped to the surface. The bentonite is separated from the gravel (7) and sand (8) and returned to the shield.

between Rotherhithe and Wapping (begun 1825). After much delay, the tunnel was finally completed in 1843.

The Rotherhithe Tunnel, today part of the London Underground but originally designed for pedestrians, was followed (1869–70) by a small-diameter, 402-m (1,320-ft) pedestrian tunnel at Tower Hill, driven in 1 year by Peter Barlow and James Henry Greathead using a cylindrical shield designed by Greathead. The Greathead technique, employing compressed air to keep water out of the heading (the tunnel face in front of the shield), became the accepted method for tunneling soft ground.

In the United States, De Witt Haskins pioneered (1874) the use of compressed air and the air lock in an enterprise under the Hudson River at New York City. Haskins did not use a shield, and two serious blowouts killed 20 workers, forcing temporary abandonment of the project. The East River Gas Tunnel, excavated by Charles M. Jacobs in 1892–94, finally brought together the shield, compressed air, and airlock (see CAISSON), and the same technique was used (1904) to complete Haskins's Hudson project (today part of the Hudson Tubes) and other Hudson tunnels.

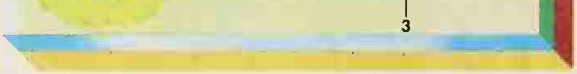
The automobile created a new problem, that of ventilating lethal carbon monoxide fumes. Clifford Holland solved this problem in the Holland Tunnel (1927), under the Hudson River, by using a system of fans and air ducts.

Construction

Even though engineers today employ some new technological devices, they continue to use many of the established techniques.

Soft-Ground Tunneling. The basic tool for tunneling through soft ground, especially in water-bearing strata, remains the shield. In its modern form the shield has a circular cross section with a cutting edge driven forward by powered jacks. Material excavated through working pockets in the face is removed by conveyor or cars on rails. In tunneling under rivers, the use of compressed air is often necessary; workers enter and leave through an air lock, with a decompression chamber used to prevent the BENDS.

In the immersed-tube method of tunnel construction, an underwater trench (1) is first dredged and leveled with a sand-aggregate foundation (2). Prefabricated steel or prestressed-concrete tunnel sections are sealed with temporary bulkheads, floated into position between pontoons (3), and sunk end to end into the trench by filling the ballast tanks (4) with water. Divers bolt or weld (5) the sections together. The completed tunnel segments are then covered with earth (6), and the bulkheads are removed to permit fitting out.



A subaqueous tunneling technique perfected (1906–10) by W. J. Wilgus for a railroad tunnel under the Detroit River, called the build-and-sink, or immersed-tube, method, has become steadily more popular for large vehicular tunnels under rivers. A trench is first excavated and leveled in the river bottom. Sections of concrete-lined steel tube or prestressed concrete are sealed at both ends with temporary bulkheads and towed into place over the trench. The sections are then ballasted, sunk in the trench, and coupled by divers. When the tunnel is complete, it is covered over for protection. For SUBWAYS, a widely used technique is the cut-and-cover method, which limits disruption by excavating a short section from the surface and immediately covering it over.

Rock Tunneling. Tunneling through hard rock with explosive charges follows the long-established cycle of drilling, planting the charges, blasting, ventilating, and mucking (clearing the tunnel of debris); the process has been greatly accelerated, however, by high-speed drilling machinery. Full-diameter drilling and blasting was pioneered (1958–65) in the 11.7-km (7.2-mi) Mont Blanc vehicular tunnel between France and Italy. To reinforce the rock where cracks have developed, steel bolts are used.

The most important modern development in rock tunneling is full-face boring, a technique pioneered in 1882, when Col. Frederick Beaumont invented a machine to bore through chalk for the English Channel Tunnel project. The Channel Tunnel, or "Chunnel," a cooperative Anglo-French project, has been begun twice within the past century or so. It was stopped once, in 1883, because of British fears of invasion, and again in 1974, because the binational supersonic CONCORDE proved a more attractive project. In 1986 a 3-tunnel scheme was agreed on by the two countries, and work was begun in early 1988. Adaptations of Beaumont's machine, called moles, have been used since the 1950s. Their round heads—some more than 9.1 m (30 ft) in diameter—have rotating cutters that bite away and toss soil or rock to bucket conveyors on the head edge. Mole machines are used in the Chunnel, as they are used on land, especially in mountains where blasting often weakens the rock surrounding the tunnel.

Undersea Tunneling. The first tunnels built under the ocean floor were the 10-km (6.2-mi) Japanese Kanmon railroad tunnels (1936–44), for which both rock and soft-ground techniques were used. The Seikan Tunnel, completed in 1988, links the Japanese islands of Honshu and Hokkaido. It is the world's deepest underwater tunnel and the longest transportation (railroad) tunnel, with a length of 54 km (33 mi).

See also: COAL AND COAL MINING.

tunnel effect In physics, the tunnel effect, or tunneling, is a phenomenon in which electrons or other elementary particles move through sufficiently thin potential barriers. Theoretically, it is explained by QUANTUM MECHANICS and application of the Schrödinger wave equation. Treated as waves, electrons and other small particles can be described by wave equations, the solutions of which predict a small probability for the tunneling of particles through thin layers of solid or vacuum. The tunnel effect is exploited in a number of scientific applications, including semiconductors, sensitive electronic measuring instruments, and molecular-level microscopy.

Tunney, Gene [tuhn'-ee] James Joseph "Gene" Tunney, b. New York City, May 25, 1898, d. Nov. 7, 1978, was an American heavyweight boxing champion. He lost only one fight in his career, to Harry Greb, as a light-heavyweight, whom he later beat. Tunney, a masterful boxer, easily gained a 10-round decision over the heavyweight champion Jack DEMPSEY, previously considered unbeatable, on Sept. 23, 1926, in Philadelphia. He defended the title against Dempsey on Sept. 22, 1927, in Chicago—the famous "long count" fight, in which Tunney recovered from a knockdown to score a convincing decision. Tunney retired in 1928 with a record of 56 victories (41 by knockout), 1 loss, 1 draw, 17 no-decisions, and 1 no contest. He was elected to the Boxing Hall of Fame in 1955. Tunney's son, John Varick Tunney, b. New York City, June 26, 1934, served as Democratic congressional representative (1965–70) and U.S. senator (1971–77) from California.

Tupí [too-pee'] Tupí, or Tupí-Guaraní, is one of the most widespread native American languages in tropical South America. Traditionally, cultural variations were great among Tupian-speaking peoples, although tropical forest horticulture with manioc as the principal crop and hunting and fishing were important activities for all groups. Religion was shamanistically oriented (see SHAMAN), and the extended family formed the basic social unit. Many Tupian groups on the lower Amazon were exceedingly warlike; some are alleged to have practiced cannibalism.

From a center of origin probably south of the Amazon, various Tupian-speaking groups migrated in several directions until the late 16th century. The Tupinambarana, for example, journeyed along the Amazon to the Madeira until they reached its headwaters in Bolivia. The Omagua reached the mouth of the Juruá River. The Tupinambá crossed eastern Brazil to the Atlantic and also migrated south to Porto Allegre, a distance of 3,200 km (2,000 mi). Tupians who moved inland were called the Guaraní of Paraguay; those who reached the frontier of the Inca empire were known as the Chiriguano. Tupian-speakers constituted one of the largest native populations at the time of the Spanish conquest.

Tupper, Sir Charles [tuhp'-ur] Sir Charles Tupper, b. Amherst, Nova Scotia, July 2, 1821, d. Oct. 30, 1915, premier (1864–67) of Nova Scotia and prime minister (1896) of Canada, led Nova Scotia into the Canadian Confederation in 1867 over great opposition. Tupper, a physician, sat in the Nova Scotia assembly as a Conservative (1855–67). After serving as provincial premier, he won election to the Canadian House of Commons in 1867 and served there until 1884. He was a cabinet member (1870–73, 1878–84) during both of the administrations of Sir John A. Macdonald. Tupper served as high commissioner to London (1884–87, 1888–96), returning to Canada to become prime minister. After a few months in office he was forced to resign when the Conservatives were defeated at the polls. He led the opposition (1886–1901) until his retirement.

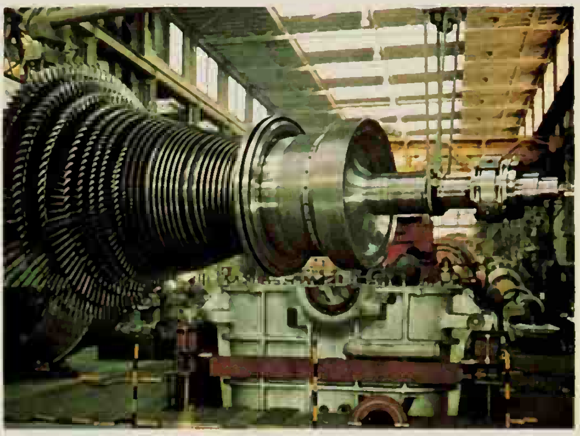
turbine [tur'-buhn] A turbine is a rotary machine that converts the kinetic energy in a stream of fluid (gas or liquid) into mechanical energy. The stream of fluid is guided to a rotor, a wheel that is mounted to a shaft from which power is taken. The fluid strikes a series of buckets, fins, or blades on the rotor, and the energy in the fluid makes the rotor spin. Turbines are an example of Newton's third law of motion, which states that for every action there is an equal and opposite reaction. The earliest known turbine was built (AD *c.*75) by the Greek inventor Hero of Alexandria. His device was a hollow ball that spun in reaction to jets of escaping steam. Although only a toy, this early reaction turbine demonstrated the principle later used in the aircraft jet engine.

Turbines may be classed as impulse turbines or reaction turbines, depending on the force that causes the rotor to revolve. An impulse turbine is driven by the force of a fluid striking it. In a reaction turbine, such as Hero's toy, nozzles are mounted on the rotor and revolve with it.

The three main types of turbines are classified on the basis of the fluid that supplies the driving force: the gas turbine, the steam turbine, and the water, or hydraulic, turbine (see WATERWHEEL; HYDROELECTRIC POWER).

Gas Turbine. The gas turbine is a rotary engine that converts heat energy into mechanical energy by a contin-

The rotor of a steam turbine is lowered into its casing during assembly. Its components include (from left) *the large blades of the low-pressure stage; the medium-sized and small blades of the reaction stage; the Curtis wheel; and the drive-shaft mechanism.*



uous process that compresses, heats, and expands a gas. The basic gas turbine was patented in England in 1791 by John Barber. In 1930, Frank Whittle in England was granted the first of his many patents for aircraft jet engines, which are essentially gas turbines.

A typical gas turbine has an axial or centrifugal air compressor that furnishes a continuous supply of air to a combustion chamber; the compressor and combustion chamber constitute the gasifier section of the turbine. In the combustion chamber, fuel is added to the air and then ignited. When the fuel burns, it produces a hot, high-pressure gas. As the gas leaves the combustion chamber, it spins the power-turbine rotor (the power section), which provides power and also drives the air compressor. The net power available for work from a gas turbine is the power available from the gases minus the power required to turn the compressor.

Generally, if power is taken mechanically from the shaft of the power-turbine rotor, the engine is called a gas turbine. In a jet engine, however, propulsion is provided by a powerful stream of exhaust gas (see JET PROPULSION).

Steam Turbine. A steam turbine is a rotary machine that converts the heat energy of steam into mechanical energy. Steam turbines developed little from the time of Hero to the end of the 19th century, at which time Carl Gustaf de Laval, a Swede, built several successful single-stage turbines ranging in size from five to several hundred horsepower.

In a typical steam turbine, steam strikes against curved or angular blades fastened to the movable rotor and causes it to spin. The steam then meets another set of blades that are fastened to the casing, or stationary shell, of the turbine; these blades redirect the steam so it can effectively push against the next set of rotor blades. This process is repeated as the steam travels the length of the turbine through the various stages.

Steam turbines provide more than 80 percent of the electricity generated in the world and power most of the world's largest ships.

See also: POWER, GENERATION AND TRANSMISSION OF.

turbot [tur'-buht] Turbot is the common name for several species of FLATFISHES (flounders). The true turbot, *Scophthalmus maximus*, a popular food in Europe, is found in the Mediterranean and along the Atlantic coast of Europe. Brownish and almost circular, it has both eyes on one side and lies buried on the bottom on its blind side. American flounders of the family Pleuronectidae that are called turbots include the spotted turbots, genus *Pleuromichthys*, of the Pacific, and the Greenland halibut or turbot, *Reinhardtius hippoglossoides*, of the Atlantic.

Turenne, Henri de La Tour d'Auvergne, Vicomte de [too-ren'] Marshal Henri de La Tour d'Auvergne, vicomte de Turenne, b. Sept. 11, 1611, d. July 27, 1675, was one of the greatest military officers in French history. From 1630 to 1642 he fought in nearly every theater of the conflict directed by Cardinal Richelieu, the French minister, against the Spaniards in the Thirty Years' War. Richelieu always trusted Turenne, but Cardinal Mazarin, who succeeded Richelieu in 1643, accorded the vicomte less confidence. Until the Peace of Westphalia (1648), Turenne and his colleague and rival Louis II, prince de Condé, campaigned against the Habsburgs in Germany. Condé's impetuosity was matched by Turenne's reserve and careful planning.

During the civil wars of the Fronde (1648–52), Turenne was induced by Condé's sister, the duchesse de Longueville, to side with the rebels. In 1651, however, Turenne became reconciled with the crown; he served Mazarin and defeated Condé at the Battle of Saint-Antoine (1652). From 1653 until the Peace of the Pyrenees in 1659, Turenne campaigned against Spain in Flanders, while Condé served the enemy. The Battle of the Dunes (June 14, 1658), near Dunkerque, was Turenne's greatest victory over his rival. He campaigned for Louis XIV against the Spanish (1667–68) and the Dutch and the Germans (1672–75) and was killed in battle in Germany.

Turgenev, Ivan [toor-gayn'-yif] Ivan Sergeyevich Turgenev, b. Orel province, Nov. 9 (N.S.), 1818, d. Sept. 3 (N.S.), 1883, was one of Russia's greatest writers. Educated in Moscow and Saint Petersburg, and having studied philosophy in Berlin, he was sympathetic to liberal Western opinions. Turgenev wrote some poetry in the 1840s but soon discovered that prose fiction was his proper domain. Among his plays—all written early in his career—*A Month in the Country* (1855; Eng. trans., 1933) anticipates Anton Chekhov.

Turgenev's fame was established by *A Sportsman's Sketches* (1847–52; Eng. trans., 1855), a cycle of stories about the landowners and serfs of central Russia. *Sketches* became associated with Russian social reform and may have hastened the emancipation of the serfs.

Beginning with *Rudin* (1856; Eng. trans., 1873), Tur-

Turgenev, a 19th-century Russian writer, is believed to have hastened the abolition of serfdom through his stories of peasant life. His masterpiece, Fathers and Sons *(1862), polarized Russian society along radical-conservative lines. In addition to writing plays, novels, and essays, Turgenev helped popularize Russian literature in western Europe.*

genev produced a series of novels and stories that explore social problems such as the ideological split between the generation of the 1840s and the radical generation that followed. *On the Eve* (1859; Eng. trans., 1871) has a young emancipated Russian woman marry a Bulgarian freedom fighter. *Fathers and Sons* (1862), Turgenev's most famous work, features the nihilist Bazarov, who would like to destroy the entire structure of society and build a new order based on rational scientific principles. *Virgin Soil* (1877; Eng. trans., 1877) examines the collapse of the populist movement of the 1870s.

After 1858, Turgenev lived mostly abroad. Some of his later stories, notably "The Torrents of Spring" (1871; Eng. trans., 1874), are set in the West and are apolitical. In his best work, Turgenev constantly came back to a theme formulated in his essay "Hamlet and Don Quixote" (1860; Eng. trans., 1930)—a Hamlet, paralyzed by thought and despair, and wandering through a godless world in which blind nature is the only reality, meets a Don Quixote following a transcendent ideal.

Turgot, Anne Robert Jacques [tuer-goh'] Anne Robert Jacques Turgot, b. May 10, 1727, d. Mar. 18, 1781, was a French economic theorist, provincial administrator, and controller general of finances (1774–76) whose bold reforms of the nearly collapsed financial structure of France were blocked by the forces of privilege. A friend of the Enlightenment and a disciple of the PHYSIOCRATS, he wrote *Réflexions sur la formation et la distribution des richesses* (Reflections on the Function and Distribution of Wealth, 1766), articles in Diderot's *Encyclopédie*, and other works advocating national prosperity by freeing landed wealth from governmental controls.

At the outset of LOUIS XVI's reign, Turgot took over (1774) the controller generalship and reduced the government's massive debt by curbing court and military costs. His bold freeing of the grain trade from internal tariffs in 1775 was ill-timed, however, because a crop failure drove prices too high and triggered riots. The military was used to restore order, and in 1776, Turgot introduced the even bolder Six Edicts, abolishing guilds and replacing forced peasant road work (the *corvée*) with a tax on all landowners. Opposition by the privileged clergy and nobility and the Parlement of Paris brought about his project's collapse and his dismissal.

Turin [tur'-in] Turin (Italian: Torino), a city in northwestern Italy and capital of the Piedmont region, occupies the left bank of the Po River, 515 km (320 mi) northwest of Rome. Turin's population of 1,012,180 (1989 est.) places it fourth among Italian cities after Rome, Milan, and Naples. The center of the Italian automobile industry, Turin is a major commercial and transportation hub. Other products include textiles, aircraft, ball bearings, rubber and tires, leather goods, paper, metal goods, plastics, radios and televisions, pharmaceuticals, chocolate, wines, and clothing. A university (1404) and many museums and libraries are there. Landmarks include the Renaissance Cathedral of San Giovanni Battista (1492–98), the basilica of Superga (1717–31), and the Palazzo Madama (begun 13th century), Palazzo Reale (1648–58), and Palazzo Carignano (1680), the meeting place of the first Italian parliament in 1861.

Founded by the Taurini (hence at first called Taurasia) and subsequently destroyed by Hannibal in 218 BC, the city became a Roman military colony during the 1st century BC. After rule by Lombards (568–774) and Franks (774–888), Turin passed to the house of SAVOY in 1046 and became the capital first of the duchy of Savoy (1563) and then of the kingdom of Sardinia (1720). Following a period of French control (1798–1814), the city became the center of the Savoy-led RISORGIMENTO, or Italian unification movement, and served (1861–65) as the first capital of a united kingdom of Italy. Turin was heavily damaged by Allied bombing during World War II.

Turina, Joaquin [too-ree'-nah] Joaquin Turina, b. Dec. 9, 1882, d. Jan. 14, 1949, was a Spanish composer, pianist, and conductor. Emulating the example of Isaac Albéniz and Manuel de Falla, he wrote a large number of works for piano, orchestra, and voice evoking Spanish scenes, often those of his native city, Seville. Typical orchestral works include *La procesión del rocío* (Procession of the Virgin, 1912), *Sinfonía sevillana* (Sevillian Symphony, 1920), and *Canto a Sevilla* (Song to Seville, 1924, with soprano solo). One of his best-known pieces is *La Oración del torero* (The Toreador's Prayer, 1925) for strings.

Turing, Alan Alan Mathison Turing, b. June 23, 1912, d. June 7, 1954, was a British mathematician who is best remembered for theoretical computing devices that bear his name and are based on his ideas (Turing machines). In 1936, Turing published "On Computable Numbers," a paper in which he conceived of a machine that could move from one state to another by following a rigorous set of rules, foreshadowing the logic of digital computers. During World War II, Turing worked on breaking enemy codes. He later worked on the development of an electronic computer and on theories of artificial intelligence. Turing was arrested for violation of British homosexuality statutes in 1952. He committed suicide at the age of 41.

Turkana, Lake see RUDOLF, LAKE

Turkestan see TURKISTAN

Turkey Turkey is an independent republic occupying a region that has played a major role in world history as a bridge connecting East and West. European Turkey, known as eastern THRACE, is bounded on the north by the BLACK SEA and Bulgaria and on the west by the AEGEAN SEA and Greece. It is separated from Asian Turkey (Anatolia, or Asia Minor; see ANATOLIA, ANCIENT) by the BOSPORUS, the Sea of MARMARA, and the DARDANELLES Strait. Anatolia

AT A GLANCE

REPUBLIC OF TURKEY

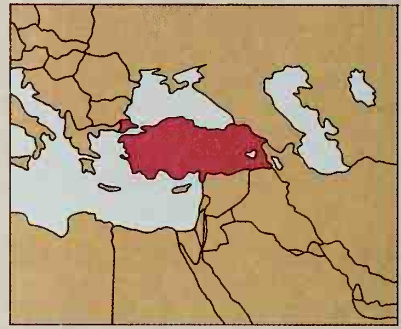
Land: Area: 779,452 km^2 (300,948 mi^2). Capital: Ankara (1990 prelim. pop., 2,553,209). Largest city: Istanbul (1990 prelim pop., 6,748,435).

People: Population (1990 prelim.): 56,969,109. Density: 73 persons per km^2 (189 per mi^2). Distribution (1990): 53% urban, 47% rural. Official language: Turkish. Major religion: Islam.

Government: Type: republic. Legislature: Grand National Assembly. Political subdivisions: 67 provinces.

Economy: GNP (1989): $75 billion; $1,360 per capita. Labor distribution (1989): agriculture—45%; manufacturing—12%; mining—1%; construction—5%; public administration, defense, and services—12%; trade—9%; transportation and communications—4%; other—12%. Foreign trade (1989): imports—$15.8 billlion; exports—$11.6 billion. Currency: 1 Turkish lira = 100 kurus.

Education and Health: Literacy (1990): 70% of adult population. Universities (1989): 28. Hospital beds (1988): 113.010. Physicians (1988): 42,502. Life expectancy (1990): women—67; men—64. Infant mortality (1990): 74 per 1,000 live births.



is bounded on the north by the Black Sea; on the east by the USSR and Iran; on the south by Iraq, Syria, and the Mediterranean Sea; and on the west by the Aegean Sea.

Turkey is one of the more developed Middle Eastern countries, and industrialization is in progress. Tourism, stimulated by the fine climate and the abundance of historic sites, such as Troy, Pergamum, and Ephesus, is beginning to gain importance. Modern Turkey was founded on Oct. 29, 1923, as the successor of the Ottoman Empire.

Land and Resources

Turkey lies within the Alpine-Himalayan mountain belt, and more than 75% of the land lies at elevations above 500 m (1,640 ft). It is one of the most active earthquake regions in the world.

The country may be divided into four physical regions: the central Anatolian plateau and surrounding mountains, the eastern highlands, the Aegean coastland, and Thrace. The central Anatolian plateau is separated from the coastal lowlands by the Pontic Mountains in the north and the Taurus Mountains in the south. The Pontic (Northern Anatolian) Mountains increase in height toward the east, where their highest peak, Kaçkar Daği (3,937 m/12,917 ft), is found. The central plateau is composed of uplifted blocks and downfolded troughs. Shallow salt lakes—Lake Tuz is the largest—and geologically young volcanic features characterize the landscape.

The eastern highlands are dotted with peaks reaching elevations of 3,000–4,500 m (10,000–15,000 ft) and surrounded by high lava-covered plateaus. The highest of the peaks is Mount Ararat (Ağri Daği; 5,122 m/16,804 ft), in the extreme east. Lake Van is a large salt lake with underground connections to the Tigris and Euphrates rivers, whose headwaters rise in the nearby mountains.

The Aegean coastland is an area of elongated mountain ridges cut by steep valleys. Thrace comprises a central plain surrounded by mountains of moderate height.

Soils. About 40% of the land, including the Black Sea coast and most of the northeast, is covered by red and gray brown podzols and by brown forest soils. The Aegean and Mediterranean coasts are characterized by mountain soils (brown forest, terra rossa, rendzina). The southeast has rich chernozems and chestnut-like soils.

Climate. Because of the mountainous terrain and maritime influence, climates vary greatly. The Aegean and Mediterranean coasts enjoy a 29° C (84° F) mean temperature in July and a 9° C (48° F) mean in January. Rainfall is concentrated in the winter; Antakya on the southern coast receives an annual average of 991 mm (39 in). The Black Sea coast is somewhat cooler, and the rainfall is heavier, averaging 2,438 mm (96 in). The northeast has warm summers but severe winters averaging −9° C (16° F). The central plateau has hot, dry summers averaging 23° C (73° F) and cold, moist winters, when temperatures average below 0° C (32° F).

Drainage. The Tigris River and the Euphrates River originate in eastern Turkey before flowing to the Persian Gulf. Most Turkish rivers are not navigable, having irregular, shallow beds and seasonal depth changes.

Vegetation and Animal Life. The Black Sea coast is the most densely forested region in Turkey, with both coniferous and deciduous trees. Much of the south, west, and northwest is covered by Mediterranean vegetation of thick, scrubby underbrush. The dry central plateau is steppe land, with short grasses, bushes, and stunted willow trees. Wild animals include the wolf, fox, bear, and wildcat. The water buffalo, camel, and Angora goat are domesticated.

Mineral Resources. Production and transport costs limit the importance of many minerals. Copper from Ergani in the Diyarbakir region and chrome from Fethiye are mined for export. The presence of coal near Eregli on the Black Sea and in Thrace and of iron ore in the Sivas region has been important to the industrialization effort. Petroleum, boron minerals, mercury, and manganese are also found.

People

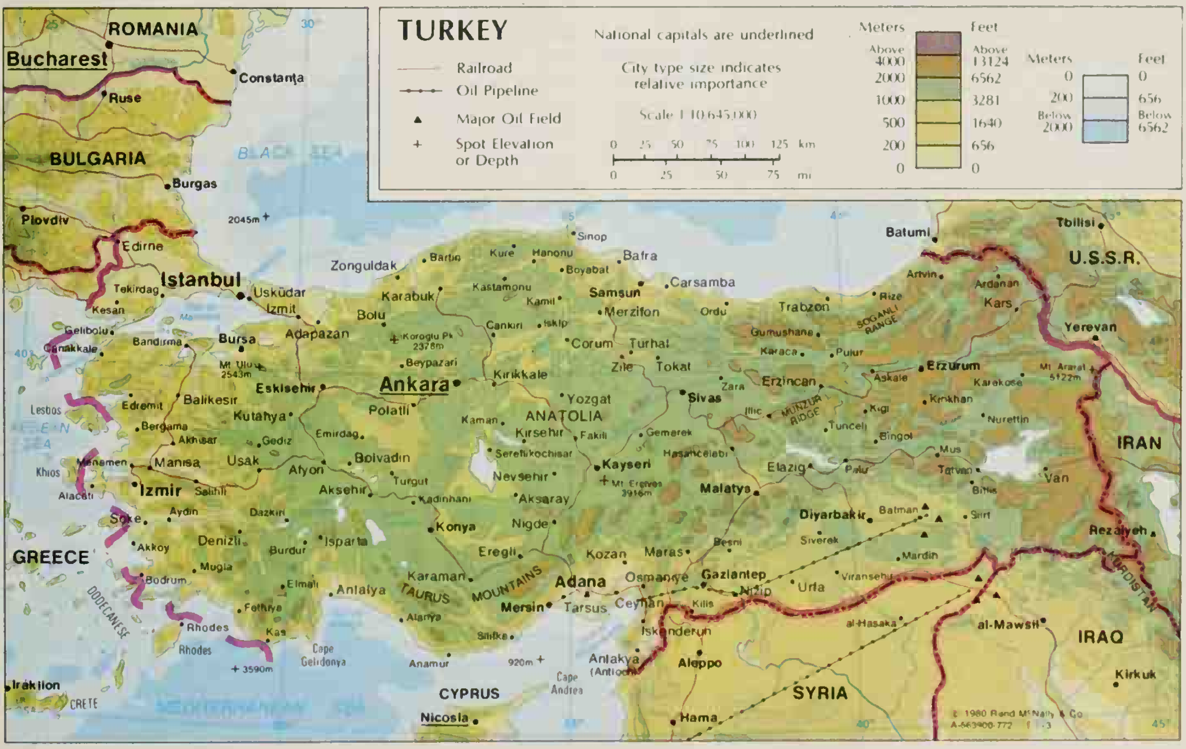
The people of Turkey are overwhelmingly TURKS (about 90%) and Sunni Muslim (98%). About 3 million KURDS live in the eastern provinces, and several hundred thousand Arabs inhabit the Hatay enclave adjacent to Syria. The number of Greeks was dramatically reduced by the population exchange between Greece and Turkey following the Treaty of Lausanne (1923). About 25,000 Jews live primarily in Istanbul, Ankara, and İzmir. The Greek Orthodox community is the largest Christian denomination, followed by the Gregorian church. Most of the population speak Turkish (see URAL-ALTAIC LANGUAGES), although minorities speak Arabic and Kurdish.

More than half the population live in urban areas. ISTANBUL is the cultural, industrial, and commercial center; ANKARA is the capital. Other major cities are İZMIR, ADANA, Antakya (or ANTIOCH), KONYA, EDIRNE, TRABZON, and BURSA. Large-scale migration to the cities since the 1950s has led to overcrowding.

Education and Health. The educational system of Turkey was modernized after the founding of the republic. Today education is mostly public and free. Funds, teachers, and facilities are scant in remote areas of the country. The University of Istanbul (1453), the Aegean University (1955) at İzmir, and the Middle East Technical University (1956) at Ankara are Turkey's largest institutions of higher learning.

Medical services are free to the poor. Although health service is improving, rural areas suffer shortages of physicians and facilities; the infant mortality rate is close to the average for an Asian country.

The Arts. Although Islam dominated artistic expression under the Ottomans (see ISLAMIC ART AND ARCHITECTURE), Turkish culture since 1923 has been imbued with the spirit of nationalism. Turkish literature has been affected from both the East (chiefly Persia) and the West (mainly France). Many writers focus on life in Turkish villages. Modern painting and sculpture are of limited appeal; the people prefer folk art and decorative crafts. Traditional Ottoman music continues to be popular, although Western-style music is making inroads.



Economic Activity

Turkey's economic development began in the mid-1920s under Kemal Atatürk, first president of the Turkish republic, who attempted to Westernize and industrialize the economy. After World War II the Marshall Plan and Turkish membership in the Organization for Economic Cooperation and Development (OECD) further encouraged development. The per capita income, however, remained lower than in most industrialized countries. Turkey receives significant financial aid from the European Community (EC), to which it applied for membership in 1987. Many Turks work abroad, which helps to keep unemployment under control; remittances from these workers provide a major source of foreign exchange.

Manufacturing and Energy. Food processing accounts for one-third of all manufacturing, textiles and clothing for about 20%. Steel production, particularly at Eregli and Iskenderun, is also important. Other major industrial products include machinery and metal goods, vehicles, petrochemicals, fertilizers, and pulp and paper. Iskenderun is the terminus of an important oil pipeline from Iraq, and petroleum-based industries are being developed in the region. Despite relatively low energy needs, the cost of imported petroleum is a heavy burden, and an effort is being made to develop other energetic sources, especially by building hydroelectric plants on the Euphrates River. The construction of the country's first nuclear power station was postponed following the Chernobyl accident in 1986.

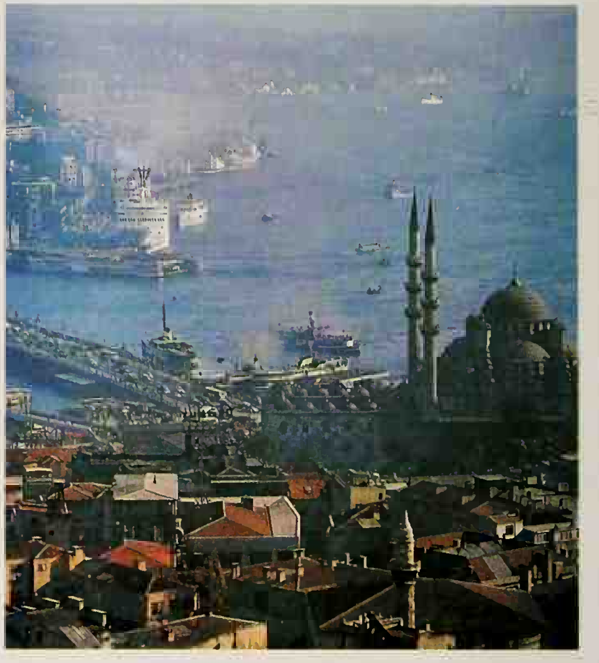
Agriculture, Forestry, and Fishing. Agriculture accounts for less than 20% of the GNP, although it employs well over half of the labor force. Cereals are the principal crop. Vegetables, grapes, sugar beets, potatoes, and oilseeds are also grown, and cattle, sheep, goats, and poultry are raised. Overgrazing is a problem in many parts of the country. Forests cover more than 25% of the land. Much of the wood harvest is used for energy. The commercial fishing industry is being developed.

Transportation. Turkey is an important transit route from Europe to the Middle East, and long stretches of railroads were built by foreign powers through Turkish territory. The first bridge across the Bosporus was completed in 1973; a second is under construction. Istanbul has the nation's major international airport and is one of the world's major ports.

Trade. Principal exports include cotton, fruits, nuts, tobacco, metals, cereals, textiles and clothing, and livestock. Imports include machinery, chemicals, crude oil, base metals, fertilizers, mineral products, and vehicles. Middle Eastern nations are beginning to rival Western European countries and the United States as Turkey's trading partners.

Government

From 1973 to 1980 the country had a series of weak coalition governments that were unable to handle increasingly serious economic problems and political violence. The prime ministership alternated between Süleyman Demirel of the moderate right Justice party and Bülent Ecevit, leader of the moderate left Republican People's party. In 1980 the military deposed Demirel in a bloodless coup led by Gen. Kenan EVREN. (Turkey previously was under military control from 1960 to 1961 and from 1971 to 1973.) In 1982 the voters approved a new constitution, which established an authoritarian presidential system and installed Evren as president for a seven-year period. Elections for a unicameral national assembly were held in November 1983. The ruling National Security Council was then dissolved and Turgut Özal, head of the newly formed conservative Motherland party, became prime minister. In the 1987 elections the Motherland party received 36% of the vote. Özal was elected president in November 1989.



Istanbul (formerly Constantinople), Turkey's largest and commercially most important city, was the capital of the Byzantine and Ottoman empires.

History

Anatolia is one of the oldest continually inhabited regions in the world, and it has repeatedly served as a battleground for foreign powers. The earliest major empire in the area was that of the HITTITES, from the 18th through the 13th century BC. Subsequently, the Phrygians (see PHRYGIA), an Indo-European people, achieved ascendancy. The most powerful of Phrygia's successor states was LYDIA. Coastal Anatolia (IONIA) meanwhile was settled by Greeks. The entire area was overrun by the Persians during the 6th and 5th centuries and fell to Alexander the Great in 334 BC. Anatolia was subsequently divided into a number of small Hellenistic kingdoms (including BITHYNIA, CAPPADOCIA, PERGAMUM, and PONTUS), all of which had succumbed to Rome by the mid-1st century BC. In AD 324 the Roman emperor CONSTANTINE I chose Constantinople, now Istanbul, as the capital of the Roman Empire. It subsequently became the capital of the Eastern Roman Empire, or BYZANTINE EMPIRE.

In 1055 a group of Central Asiatic Turks, the SELJUKS, conquered Baghdad and established a Middle Eastern and Anatolian empire. After this empire was broken up by the Mongol invasion, a new state, ruled by the Ottoman dynasty, gradually spread from northwestern Anatolia and in 1453 captured Constantinople. At the peak of its power the OTTOMAN EMPIRE controlled much of the eastern Mediterranean. The Ottomans had a sophisticated administrative system and also organized the first standing army in Europe, the JANISSARIES.

As the Ottoman Empire began to collapse in the 18th and 19th centuries, it became a battleground for rival European powers (see EASTERN QUESTION). These rivalries led to the Russo-TURKISH WARS, the CRIMEAN WAR, and the BALKAN WARS. By the outbreak of World War I the Ottoman Empire had essentially been divided into spheres of influence by the great European powers, but a reform movement was active within the Ottoman Empire itself. The YOUNG TURKS brought about a revolution in 1908 and were successful in introducing civil and social reforms.

The Ottomans were drawn into World War I on the German side. At the end of the war the empire was formally dissolved, and the Allies divided it among themselves. In 1922, however, the Turks, led by Mustafa Kemal (later known as Kemal ATATÜRK) and İsmet İNÖNÜ, defeated the armies occupying Anatolia. İnönü then won what has been called "the greatest diplomatic victory in history" when the Treaty of Lausanne (see LAUSANNE, TREATY OF) recognized the Republic of Turkey.

The republic was declared on Oct. 29, 1923. Atatürk was elected its first president. Shifting the capital from Constantinople to Ankara, he moved to transform Turkey into a modern Western state, separating church and state, emancipating women, and adopting Western law and the Roman alphabet. Although theoretically head of a constitutional democracy, Atatürk ruled as a virtual dictator until his death in 1938.

Turkey remained neutral in World War II until it joined the Allies in February 1945. Turkey joined the North Atlantic Treaty Organization (NATO) in 1952.

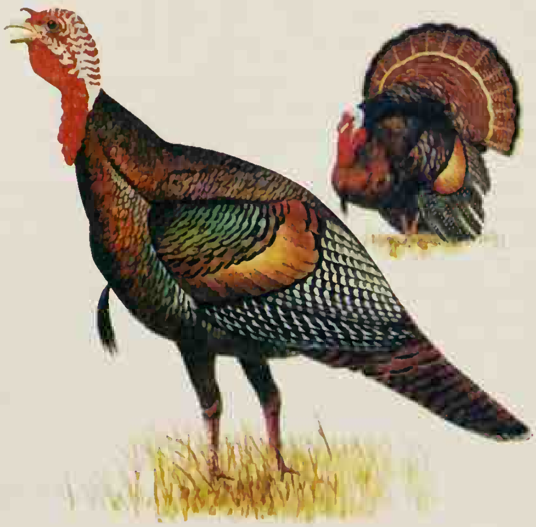
Atatürk had been succeeded as president by İnönü. Control of the government was then gained by Prime Minister Adnan MENDERES of the Democrat party. The excesses of his administration led to a coup in 1960 by Gen. Cemal Gürsel and to Menderes's execution in 1961. A new constitution was adopted in 1961, and İnönü became prime minister.

In 1964 the age-old enmity between Greece and Turkey was inflamed by fighting on CYPRUS between the Greek and Turkish sections of the population. Turkish troops invaded the island in 1974, occupying the northern portion of it. Cyprus was subsequently partitioned, and a separate Turkish Republic of Northern Cyprus was created in 1983. Meanwhile, the seizure of power by Turkish military leaders in September 1980 and the imposition of martial law drew criticism from the European Community, which Turkey hoped to join. Civilian government was restored in 1983, martial law was ended in 1985, and parliamentary elections in 1987 gave a majority to Prime Minister Turgut Özal's Motherland party. After the 1991 elections, Suleyman Demirel of the True Motherland party formed a left-center coalition government. Iraq's defeat in the 1991 GULF WAR and the breakup of the USSR and Yugoslavia heightened regional ethnic tensions and increased Turkey's strategic importance in the post–cold war world.

turkey The turkey is a large game bird native to North American forested areas and now raised commercially for food in most parts of the world. Two species—the wild turkey, *Meleagris gallopavo*, of the eastern and central United States and Mexico, and the ocellated turkey, *Agriocharis ocellata*, of Mexico's Yucatán Peninsula and adjacent areas—make up the family Meleagrididae, which is classified with pheasants in the order Galliformes. An adult male wild turkey is about 1.2 m (4 ft) long and has broad rounded wings and tail and long, slim, spurred legs. A tuft of hairlike feathers hangs from the breast, and brightly colored growths called caruncles and a pouchlike area called a wattle mark the throat region. The smaller ocellated turkey lacks the tuft of breast feathers, is more brilliantly colored, and has bright eyespots on the tail coverts. Turkeys feed on acorns, seeds, berries, and insects.

Domestication of the turkey probably began in Mexico. The Spanish carried the bird to Europe in the 16th century, and the English colonists brought domesticated turkeys with them to America in the 17th century. Several

The male wild turkey generally has iridescent green and brown plumage, a red snood over the bill, and a red wattle and caruncles on the throat. During courtship (background) *it fans its tail feathers, struts, and gobbles to attract a group of females.*



varieties have been developed, including the popular Beltsville white.

See also: POULTRY.

Turkic languages see URAL-ALTAIC LANGUAGES

Turkish language see URAL-ALTAIC LANGUAGES

Turkistan [turk'-is-tan] Turkistan (or Turkestan) is the historical name for a Central Asian region inhabited by peoples who speak Turkic languages (see URAL-ALTAIC LANGUAGES). The area includes the former Soviet republics of Kazakhstan, Kyrgyzstan, Turkmenistan, and Uzbekistan and the Xinjiang (Sinkiang) region of northwestern China. Tajikistan, another Central Asian country, is not considered part of Turkistan because the Tajik speak an Iranian language. The region is bounded on the west by the CASPIAN SEA, on the north by Siberia and Mongolia, on the south by Iran, Afghanistan, and Tibet, and on the east by China proper.

The region consists of dry steppe in the north and desert in the south. Among the great deserts of Turkistan are the KARA KUM, the KYZYL KUM, and the TAKLI MAKAN. Most of the region is drained by rivers that flow into inland seas and lakes. The AMU DARYA and the SYR DARYA flow into the ARAL SEA; the Ili River flows into Lake Balkhash; and the TARIM RIVER flows into a depression occupied by the salt lake LOP NOR. The TIAN SHAN mountain system divides Turkistan into a western, formerly Soviet, portion and an eastern, or Chinese, portion.

Turkmenistan Turkmenistan, known as Turkmenia before its independence in 1991, was one of the former Soviet republics. Located in Central Asia, it is bounded on the west by the Caspian Sea, on the north by Kazakhstan and Uzbekistan, on the east by Uzbekistan, and on the south by Afghanistan and Iran. It has an area of 488,100 km^2 (188,456 mi^2) and a population of 3,714,100 (1991 est.). The capital is ASHKHABAD (1989 pop., 398,000).

More than 80% of Turkmenistan is desert, consisting of the KARA KUM (black sands). Along the boundary with Iran lies the Kopet Dagh, a mountain range that rises to 2,941 m (9,650 ft).

The population is concentrated in oases along the AMU DARYA river, which flows near the republic's eastern border with Uzbekistan; along the foot of the Kopet Dagh in the south; and in oases watered by the Murgab and Tedzhen rivers. The Turkmen, or Turkoman, who constitute 72% of the population, are SUNNITE Muslims. They are related to Anatolian Turks and speak a Turkic language. About two-thirds of the Turkmen still live in rural areas. Ethnic Russians, who account for 10% of the population, live almost exclusively in cities. About 9% are Uzbeks. Major cities—in addition to Ashkhabad—are Chardzhou, Tashauz, Mary, Nebit-Dag, and Krasnovodsk.

Agriculture is facilitated in the dry climate by the Kara Kum Canal, which irrigates the desert with water drawn from the Amu Darya. The Turkmen oil fields are a promising source of future wealth.

The Turkmen appeared as an ethnic group about AD 1000. Militarily skillful, they frustrated Russian and British expansion until the latter half of the 19th century. The region that is now Turkmenistan was conquered by tsarist Russia in the 1870s and 1880s. After the Bolshevik Revolution of 1917, the Soviet regime gained control only in 1923 and established the Turkmen republic in 1924. Following the demise of the USSR, Turkmenistan became independent, but the power continues to be held by the former Communist party chiefs.

Turkoman see TURKMENIA

Turks Turks, or Turkic peoples, are the principal descendants of large bands of nomads who roamed in the Altai Mountains (and thus are also called the Altaic peoples) in northern Mongolia and on the steppes of Central Asia during the early centuries of the Christian era. Their language is a branch of the URAL-ALTAIC family.

6th to 9th Centuries. The original Central Asian Turkic nomads established their first great empire in the 6th century AD, a nomadic confederation that they called Gök Türk (Sky Turk) and that the Chinese called Tu Kiu. This empire stretched across the steppes from Transoxiana to northern China and the Pacific Ocean and developed some of the characteristic features of subsequent Turkish culture: military organization, tactics, and weapons, and political and social structure and titles. Gök Türk broke up in the 7th century. The eastern part of the confederation became assimilated with Chinese civilization and gave rise to the MONGOLS. The western part was strongly influenced by the Islamic civilization of the Middle East.

In the 8th century the Karluk settled in the I-li and Chu river valleys between the Issik-Kul and Balkhash lakes. The UIGHUR remained in northern Mongolia, and the Kirghiz wandered in the steppes to the north. The Oghuz (or Ghuz) Turks, called the Turkmen (Turkoman) in Europe, dominated the area between Mongolia and Transoxiana.

9th to Mid-13th Centuries. Under the leadership of the SELJUK warrior family, the Oghuz tribes entered Iran and then other parts of the Middle East as raiders and mercenaries. The Seljuks soon emerged (1055) as secular rulers, or sultans, of the entire Islamic Middle East with the exception of Egypt and Syria, which remained under Shiite FATIMID rule. The ABBASID caliphs remained only as religious leaders, with no real power. The Seljuks developed the madrasahs, or Islamic colleges; these were centers of a religious and bureaucratic revival, whereas the sultanate became the legal basis for administrative reorganization and codification. As they gained control of the settled state, they developed a slave army of MAMELUKES and in the late 11th century drove the nomad mercenaries into the lands of their enemies, primarily the Christian Byzantines, Armenians, and Georgians of Anatolia and the Caucasus, precipitating an overwhelming Turkish conquest and transformation of Anatolia into the homeland of the Turks.

The Seljuk empire of Rum, or Roum (1063–1300), with its capital at Konya (Iconium), dominated most of Anatolia. After 1150, Turkmen leaders established their own principalities along the fringes of the empire, where they acted as ghazis, or fighters for the faith of Islam against the infidels. The Great Seljuks defended Syria and Palestine against incursions during the CRUSADES.

In the meantime, in Central Asia the Kirghiz pushed the Uighur out of Mongolia in the late 9th century. The Uighur moved south into Xinjiang, in northern China, and west into Transoxiana. The Kirghiz finally settled in the mountains of what is now the USSR, where they remain today. The Mongols of north China were formed into a powerful military confederation under the leadership of GENGHIS KHAN about 1200. They conquered China and the Asian steppes and by the middle of the 13th century had invaded and conquered the Seljuk-Abbasid Middle East as well as Anatolia. The Mongols brought substantial devastation; at the same time, however, they introduced Christian and Buddhist elements from Central Asia and established trade and cultural relations between the Middle East and China.

Mid-13th to 20th Centuries. When the great Mongol Empire was broken up among the sons of Genghis Khan, the Mongol dynasty of the Ilkhans, founded by Hulagü, took control of the Middle East from 1256 to 1353. Subsequent Ilkhanid decline led to new anarchy and the threat of a renewed Mongol invasion of the Middle East by the GOLDEN HORDE, which ruled southern Russia, and later by forces under the powerful conqueror TIMUR. Ultimately, one of the Turkmen principalities built the OTTOMAN EMPIRE, starting in the 14th century. Using an army of Oghuz nomads and Christian mercenaries, the Ottomans conquered southeastern Europe as far as the Danube in the 15th century. Then, after taking Byzantine Constantinople in 1453, they went on to overrun Egypt, Syria, and Arabia in the early years of the 16th century and Iraq, western Iran, and the Caucasus in the east and Hungary in the west in the middle of the century. The Ottoman Empire then began a long decline that finally led to its breakup after World War I.

The Turkish conquest of Anatolia had caused a substantial displacement of the native Christian population there. Little ethnic change resulted in southeastern Europe, however, except for areas of Serbia, Albania, and Greece, where the Turkish tribes settled, and in Bosnia, where the indigenous Slavic BOGOMILS converted to Islam because of previous Christian persecution. Muslims and Christians alike were allowed to retain their religious and national traditions within autonomous settlements. These ultimately became the centers for national movements and independent states that rose on the ruins of the Ottoman Empire in the 19th and 20th centuries.

Present Distribution. In 1990 an estimated 48 million Turks were living in Turkey. Most of the Turkish inhabitants of the independent states of southeastern Europe had been massacred or driven out, but about 1.3 million still survived (1980) in Greece, Bulgaria, Cyprus, Albania, Romania, and southern Yugoslavia. About 29 million modern descendants of the Oghuz and their Turkic relatives lived in the USSR: 1 million Turkmen, concentrated in the deserts east of the Caspian Sea and north of Iran; 9 million Kirghiz, in northeastern Central Asia bordering China; 4.5 million Kazakh; 1 million Crimean TATAR; 5.2 million Kazan Tatar, who live in the central Volga River valley; 4 million Azeri Turks, who live in the Azerbaijan SSR in the Caucasus, as well as another 4 million in the northwest Iranian province of Azerbaijan; and 300,000 YAKUT, who were pushed by the Mongols into Siberia. The Gagauz of BESSARABIA and the DOBRUJA Turks have been largely destroyed as communities, although many survive in Turkey and in European states.

Turks and Caicos Islands [kay'-kuhs] The Turks and Caicos Islands are a group of about 30 islands in the British West Indies that form the southeast continuation of the Bahamas. The total area is 430 km^2 (166 mi^2), and the population is 7,436 (1980). Only seven of the islands are inhabited, including Grand Turk (1980 pop., 3,146), where the seat of government is located; Salt Cay; Grand Caicos, the largest island; and South Caicos, site of Cockburn Harbor. Grand Turk also serves as a U.S. guided-missile tracking station. The economy is based on fishing, tourism, and financial services. The islands, sighted by Juan Ponce de León in 1512, were later claimed by Britain but were not permanently settled until 1776. At various times they were ruled from other British colonies in the area—Bermuda, the Bahamas, and Jamaica.

Turku [toor'-koo] Turku (Swedish: Åbo), a port city in southwestern Finland, lies at the mouth of the Aurajoki River on the Gulf of Bothnia, about 160 km (100 mi) northwest of Helsinki. With a population of 159,346 (1990 est.), Turku ranks as Finland's third largest city. It is an industrial city with shipyards, food-processing plants, steel and textile mills, and pottery works. The Swedish University of Åbo (1917) and the University of Turku (1920) serve, respectively, the Swedish and Finnish populations of this bilingual city.

Turku began as a trading center just north of its present location. During the 13th century the city moved south and began to grow around its cathedral (1290) and castle. Before the Russian takeover in 1812, Turku was Finland's largest city and served as its capital. The city was heavily damaged during the Russo-Finnish War (1939–40) and World War II.

turmeric [tur'-muh-rik] Turmeric is the common name for a perennial herb, *Curcuma longa*, of the ginger family, Zingiberacea, and for the dye and spice made from its tuberous roots. Turmeric is native to southern Asia and has been cultivated since ancient times in China and Indo-

Turmeric is commercially grown in tropical regions throughout the world for use as a spice and for the dye made from its dried rhizomes.

nesia; it is also cultivated in India, Jamaica, Haiti, and Peru. The plant grows about 1 m (3 ft) tall and has large leaves and yellow flowers. The rhizomes, or roots, are oven-dried and ground into a peppery-flavored orange yellow powder that is used in curries and prepared mustard.

Turner, Frederick Jackson Frederick Jackson Turner, b. Portage, Wis., Nov. 14, 1861, d. Mar. 14, 1932, was an American historian whose "FRONTIER thesis," also known as the "Turner thesis," strongly influenced the writing of U.S. history. He received (1890) his Ph.D. at The Johns Hopkins University and taught at the University of Wisconsin (1889–1910) and at Harvard (1910–24). In 1927, Turner became senior research associate at the Henry E. Huntington Library in San Marino, Calif.

At a meeting of the American Historical Association in 1893, Turner presented his famous thesis in a paper entitled "The Significance of the Frontier in American History," which altered the course of American scholarship and is still recognized as the most influential single piece of historical writing produced in the United States. Turner argued that the existence of free land and the advance of settlement westward had exerted a crucial influence on the development of American institutions and character. Democracy, individualism, practicality, inquisitiveness, mobility, optimism, materialism, and wastefulness, he contended, were rooted in the pioneer experience. The thesis induced historians to look more to the American environment in seeking to explain the course of U.S. history.

An outstanding teacher who helped build an excellent graduate history program at Wisconsin, Turner published only a few works, including *The Frontier in American History* (1920). *The Significance of Sections in American History* (1932), a posthumously published collection of his essays, won a Pulitzer Prize in 1933.

Turner, John N. The short-term Canadian prime minister John Napier Turner, b. Richmond, England, June 7, 1929, went to Canada with his family in 1932. A lawyer, Turner was elected to the House of Commons as a Liberal in 1962. He first joined the cabinet as minister without portfolio under Prime Minister Lester Pearson; in July 1968, Pierre Trudeau appointed him minister of justice. Turner became finance minister in 1972, but in 1976 he returned to private law practice. When Trudeau announced his retirement, however, Turner won the party leadership and, on June 30, 1984, was sworn in as prime minister. He called an election for September 4. On that day the Liberals were overwhelmingly defeated by the Progressive Conservatives, led by Brian Mulroney. Turner again led the Liberals in the election of Nov. 21, 1988, but the Liberals lost. In February 1990, Turner resigned as Liberal leader.

John N. Turner was the prime minister of Canada for less than three months in 1984. Turner had succeeded the retiring Pierre Trudeau as Liberal party leader and prime minister, but in the September 1984 election he and the Liberals were beaten by the Progressive Conservatives under Brian Mulroney.

Turner, Joseph Mallord William The British artist Joseph Mallord William Turner, b. Apr. 23, 1775, d. Dec. 19, 1851, is often regarded as the greatest of all landscape painters and an artist of uniquely varied ability. The steady demand for drawings of picturesque architecture prompted the young Turner to travel throughout Britain. In 1796 he began to exhibit oils at the Royal Academy. The splendidly poetic *Buttermere Lake* (1798; Tate Gallery, London) was finished, as was Turner's habit, from notations made in one of the sketchbooks he always carried.

Turner was elected to the Royal Academy in 1802 and in the same year left for a visit to France that marks the beginning of a new phase in his career. His *Calais Pier* (1803; Tate Gallery) magnificently recalls the stormy crossing. He recorded his first view of the Alps in watercolors. When the Napoleonic wars ended, he began to alternate tours on the Continent with expeditions in Britain, and his work became wonderfully varied. He liked to paint epic scenes of catastrophe in which the fury of the elements underlines humanity's insignificance within nature's scheme; an example is *The Wreck of a Transport Ship* (*c.*1805–10; Gulbenkian Foundation, Lisbon). Other works in this vein include *Burning of the Houses of Parliament* (1835; Philadelphia Museum of Art) and *Snow Storm at Sea* (1842; Tate Gallery). The mezzotinted plates of his *Liber studiorum* (1807–19) review the variety of his themes: *Historical, Mountainous,*

The "Fighting Téméraire" Tugged to Her Last Berth To Be Broken Up, *painted by the English romanticist Joseph Mallord William Turner in 1838, is a classic example of his art, embodying allegory, the glorification of nature, and consummate handling of light and color. The three-masted battleship becomes a spectral image of the obsolete past; the steam-powered tugboat, its black smoke smudging the sky, symbolizes the new industrial age. The artist has set their voyage on a glassy sea against a fiery sunset, suggesting the passing of a heroic age. (National Gallery, London.)*

Pastoral, Marine, and Architectural. Turner's visits to Italy from 1819 on made him more conscious of the effects of light and color, an interest reflected in both his watercolors and his oils. These increasingly experimental and abstract productions culminated in the beautiful Swiss watercolors of 1840–46. The well-known *Fighting Téméraire* (1838; National Gallery, London) was rivaled, some years later, by *Rain, Steam and Speed* (1844; National Gallery).

After Turner's death approximately 280 paintings and 19,000 drawings and watercolors were cataloged by John Ruskin. A new building at the Tate Gallery in London—the Clore Gallery for the Turner Collection—designed by the Scottish architect James Stirling opened in 1987. It is devoted entirely to the nearly 300 oil paintings and the 19,000 works on paper that comprise the national collection of Turner's work.

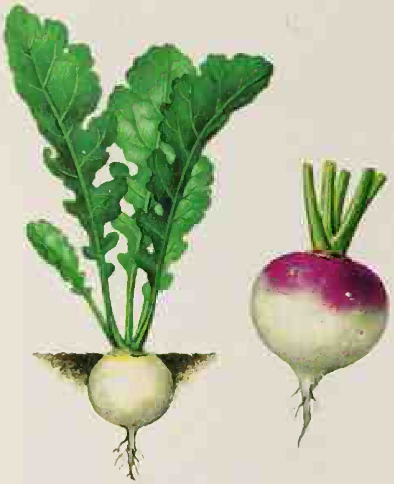
Turner, Nat Nat Turner, b. Southampton County, Va., Oct. 2, 1800, d. Nov. 11, 1831, led the deadliest black-slave revolt in U.S. history. Turner, born a slave, became a skilled carpenter as well as a preacher. He believed that he was the chosen instrument of a vengeful God; through violence he hoped to achieve retribution and freedom for his race. Interpreting a solar eclipse as the signal for action, Turner launched his insurrection on Aug. 21, 1831. His following grew to about 70, and at least 57 whites were killed before the revolt was quashed 4 days later. Turner, captured on October 30, was tried and executed. The insurrection prompted the vengeful killing of many innocent slaves and led to the enactment of stricter slave codes.

Turner, Roscoe The pioneer U.S. aviator Roscoe Turner, b. Corinth, Miss., Sept. 29, 1895, d. June 23, 1970, is best known for his many feats as a racer and stunt flyer during the 1920s. Turner won distinction as a flyer in World War I. For 8 years after his discharge in 1919, he made his living as a barnstorming stunt flyer. In 1933, Turner set a record by flying from New York to Los Angeles in 11 hours, 30 minutes.

Turner, Ted The U.S. entrepreneur and sportsman Robert Edward Turner III, b. Cincinnati, Ohio, Nov. 19, 1938, rebuilt his father's ailing billboard-advertising business and bought (1970) an Atlanta TV station that became satellite/cable "superstation" WTBS, the cornerstone of the Turner Broadcasting System (TBS). TBS launched the Cable News Network (CNN) in 1980. Turner bought the Atlanta Braves baseball team in 1976; an avid yachtsman, he won the America's Cup races in 1977.

Turner's syndrome see GENETIC DISEASES

turnip The turnip, *Brassica rapa*, of the mustard family, Cruciferеae, is a biennial herb grown as an annual. Its



The turnip has been cultivated for centuries for its nutritious roots and edible greens.

white-fleshed roots are eaten as a vegetable, and its leaves, which are rich in minerals and vitamins A and C, are used as greens. Turnips differ from RUTABAGA, or Swedish turnip, in their more globular root form and their lighter-colored flesh. Turnip roots can be stored for several months at cool temperatures.

turnpike see ROADS AND HIGHWAYS

turntable A mechanism for playing PHONOGRAPH records, the turntable consists of a platter driven by a motor at a constant speed, and a tone arm, with a stereo cartridge and stylus (needle) attached (see SOUND RECORDING AND REPRODUCTION).

Most turntables are driven either by a motor that is directly connected to the platter by a shaft, or by a belt that circles both the motor shaft and the underside of the platter. In order to keep the stylus at the correct angle in relation to the grooves, the tone arm pivots slightly as it tracks across the record. But because pivoted arms may create a slight distortion in sound, a linear-tracking system has been developed where the entire arm moves across the record, maintaining the correct angle at all times.

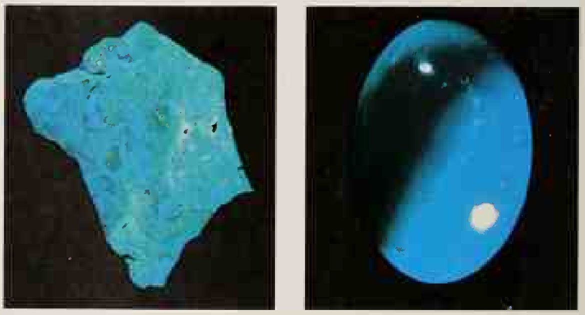
turpentine Turpentine is a clear, volatile, water-immiscible hydrocarbon fluid obtained from both the exudate of living and the heartwood of dead coniferous trees. The southeast United States has been the world's prime source since the early 1700s.

Turpentine is collected by four basic methods. Gum turpentine is steam-distilled from pine exudate collected in cups. Wood turpentine is solvent-extracted from the heartwood of stumps and taproots that have aged in the ground for 10 to 15 years. Distilled turpentine is also derived from deadwood. Sulfate turpentine is made from the resinous portion of wood pulp. Rosin is a by-product of some turpentine manufacturing processes. Turpentine was used mainly as a solvent of oil-based paints and varnishes until low-cost petrochemical solvents became available. Today it is used primarily for clean-up work.

turpentine tree Turpentine tree is the common name for *Syncarpia glomulifera* of the myrtle family, Myrtaceae. This evergreen shade tree, native to Australia, may grow as high as 60 m (200 ft), with elliptic to oblong leaves as much as 7 cm (3 in) long, and with white flowers and fibrous bark. The wood is valued for its durability and fire resistance and is used in shipbuilding, flooring, and cabinetwork. The name *turpentine tree* also refers to trees in the pine family, Pinaceae, that yield turpentine, notably the longleaf pine, *Pinus palustris*, and the slash pine, *P. elliotti*, of the southeastern United States.

turquoise Turquoise, a traditional birthstone for July, is a hydrated copper and aluminum PHOSPHATE MINERAL ($CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$) that displays a blue to greenish-blue, apple-green, or grayish color; the most highly prized variety is sky blue or robin's-egg blue. Hardness is 5 to 6, and specific gravity is 2.6 to 2.8.

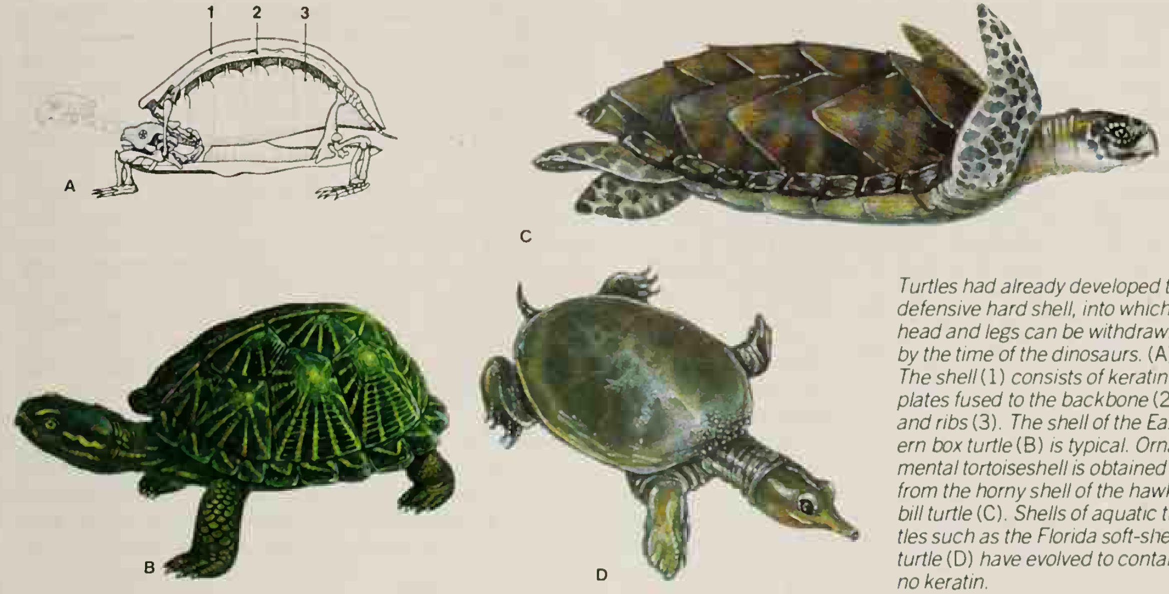
Turquoise commonly occurs in veinlets penetrating weathered, aluminum-rich, sedimentary or volcanic rocks in arid climates, and in small, fine-grained, rounded masses. Turquoise has been mined from Serabit el Khadim on the Sinai Peninsula since about 3400 BC at what may be one of the world's first hard-rock mining operations. The bracelets of Egypt's Queen Zer contain carved Sinai turquoise and are possibly the world's oldest jewelry. The name (French for "Turkish") refers to the trade of the material from the famous, still-active mines at Neyshabur, Iran, through Turkey to Europe. The deposits in the arid American Southwest have been worked since before the Spanish conquest; Pueblo Indian jewelry has been found dating from perhaps AD 900.



Turquoise (left) *is an opaque, blue to blue green copper-aluminum phosphate mineral long used as a gemstone. A turquoise gem* (right) *is most often cut in a dome-shaped, or cabochon, form.*

Turtle see BUSHNELL, DAVID; SUBMARINE

turtle Turtles are reptiles of the order Chelonia, also called the Testudines or Testudinata, characterized by a



Turtles had already developed their defensive hard shell, into which head and legs can be withdrawn, by the time of the dinosaurs. (A) *The shell* (1) *consists of keratin plates fused to the backbone* (2) *and ribs* (3). *The shell of the Eastern box turtle* (B) *is typical. Ornamental tortoiseshell is obtained from the horny shell of the hawksbill turtle* (C). *Shells of aquatic turtles such as the Florida soft-shelled turtle* (D) *have evolved to contain no keratin.*

body-encasing shell of usually fused, bony plates covered by large, horny scales. Turtles occur worldwide from the tropics to temperate regions in terrestrial, freshwater, and marine habitats. In contrast to other reptiles, whose greater diversity and abundance center in tropical regions, turtle species are most numerous in southeastern North America and southeastern Asia.

Turtle size is conventionally measured by the length of the upper shell (carapace) or the lower shell (plastron) in a straight line from front to rear. Turtles range in size from about 7.5 cm (3 in) in some specimens of the striped mud turtle, *Kinosternon baurii*, to 2.4 m (8 ft) and 725 kg (1,600 lb) in the leatherback, *Dermochelys coriacea*. The extinct sea turtle *Archelon ischyros* reached 6 m (19.5 ft) in length, as did the fossil tortoise *Colossochelys atlas*.

The earliest fossil remains of shelled vertebrates recognized as turtles are from the Triassic Period, approximately 200 million years ago. Turtles have gone essentially unchanged in anatomical appearance since that time.

Characteristics

Although the earliest-known extinct turtle had teeth on the roof of its mouth, all living turtles are toothless. The edges of the jaws are covered with a hard, sharp-edged, horny sheath, which may be smooth or have toothlike serrations.

Turtles have no external ear openings, but an ear covering (tympanum) is sometimes visible. Although their internal ear structures are well developed and able to detect low-frequency vibrations, turtles are unresponsive to airborne sounds. Their sense of smell, however, is good.

The Shell. The turtle's upper shell, or carapace, is commonly constructed of about 50 bones. These bones are believed to have evolved as new structures (dermal plates formed in embryonic connective tissue) rather than as modifications of previously existing parts of the skeleton. Unique among backboned animals, the turtle's skeletal limb-support systems—the shoulder and hip girdles—are inside the rib cage, the shoulder girdle partly adding to the formation and strength of the shell. The turtle's backbone is also incorporated into the shell for an increased degree of solidity; shortened by the loss of vertebral bones, it contains only two sacral (pelvic) and ten trunk vertebrae. The three lengthwise rows of bony plates in the upper shell are fused to the backbone and ribs beneath. The plates of the middle row are fused to the neural arches of the trunk vertebrae and are known as neural plates. On each side of this middle row is a row of costal plates, fused to the ribs of these vertebrae. The three longitudinal rows of plates are surrounded by a border of smaller plates called peripherals.

The lower shell, or plastron, typically contains nine bones: a small, single plate in front and four pairs of bony plates behind. The single plate and the first pair of plates were derived from bones of the shoulder girdle; the remaining three pairs of plates may have arisen as new structures or may be derived, at least in part, from skeletal elements. The bridge, formed by the upward-curving outer edges of the plastron, is usually present, connecting the plastron to the carapace.

The outer surface of both the upper and lower bony shell is covered by an extremely thin layer of skin, the epidermis, which contains both nerves and blood vessels. Covering this skin is a thick layer composed of large, horny scales called scutes, shields, or laminae. These scutes form the exterior shell seen on living turtles. Pressure on these scutes can be detected by nerves in the skin below. The number, position, size, and shape of the scutes are not identical to those of the bony plates beneath; indeed, it is common for the scutes to lie across the junction of two bony plates, thus lending added strength to the shell. Although marked variations do occur, the scutes of the carapace can be divided broadly into three main longitudinal rows—the vertebral scutes in the middle and a row of pleural scutes on each side—and a surrounding border of smaller scutes called marginals. Similarly, the scutes of the plastron can be broadly regarded as consisting of six pairs arranged in a double row from front to rear, plus a small scute at each leg opening. The soft-shelled turtles, family Trionychidae, lack the horny scutes and instead have their somewhat reduced bony shells covered by a thick, fleshy layer of skin. The leatherback turtle also has a thick, leathery skin, but it is ridged and embedded with small bony plates.

Respiration. Because of the rigid shell, turtles are unable to expand their "chests" to breathe. Consequently, inflation of the lungs, located just beneath the upper shell, is made possible only by altering the volume of space within the shell. Two sets of muscles at the rear of the body form the primary breathing mechanism. Broadly speaking, when these muscles are effectively contracted, they pull the internal organs up against the lungs, forcing out the air; the process is reversed in inhaling. Muscles associated with the front limbs also contribute to the breathing action: when contracted, they rotate the shoulder girdle outward, adding to the expanding space; when relaxed, they allow the shoulder girdle to return inward, reducing the space.

Many turtles can also obtain oxygen by other means. All aquatic turtles are believed able to use the tissues lining the insides of their mouths to absorb oxygen from the water. Soft-shelled turtles are able to obtain oxygen from water through the skin overlying their shells, and marine turtles have sacs in the cloaca (rectum) that are also thought capable of extracting oxygen from water.

Dormancy. Turtles in temperate regions hibernate during colder periods of the year. The ability to respire through tissues of the cloaca, throat, and skin while underwater permits some species to go for long, cold periods (weeks or months) without breathing air directly. Turtles in tropical regions and some temperate areas may estivate during hot, dry periods. An ability to shut down metabolism during unfavorable periods appears to be an adaptive trait among turtles in both aquatic and terrestrial forms throughout the world.

Feeding. Turtles as a group are omnivorous, eating both plant and animal matter, living or dead. A few species, however, are specialized feeders. Food is not chewed. The sharp cutting beak and strong throat muscles are used to force bite-sized pieces down the esophagus to the stomach.

Reproduction. Turtles mate after a period of courtship. The females of some species, such as the Eastern box turtle, *Terrapene carolina*, are able to store sperm for up to 4 years, producing fertile eggs for several seasons without additional matings.

All turtles are egg layers and all deposit their white eggs on land. The small mud and musk turtles, family Kinosternidae, lay tiny, oblong eggs about 1 to 2 cm (0.5 to 0.75 in) long, with a strong calcareous shell. The largest eggs, laid by the sea turtles, are round with a tough, leathery shell and can be up to 6 cm (2.5 in) in diameter. The time between ovulation and egg deposition is usually only a few days. Egg incubation time may be as short as 45 days for some species or more than 100 days for others. Females of some species characteristically lay only 1 or 2 eggs, whereas the sea turtles average more than 100 eggs per clutch.

Longevity. Growth rates of juvenile turtles are relatively rapid compared to those of adults. Nonetheless, individuals of some species take as long as 10 years to reach maturity. Many species display sexual dimorphism as adults, with the female sometimes being more than twice as large as the male. A unique feature of some species is the development of annual growth rings on each shell scute. Thus, the ages of young individuals can be determined before the rings begin wearing off. Turtles live much longer than most other animals. Evidence exists for captive specimens of several species that have lived for 50 years in captivity. Even in natural populations, small forms such as box turtles, *Terrapene,* and painted turtles, *Chrysemys,* of the United States have average adult ages that have been reliably estimated at 30 to 50 years.

Importance of Turtles

The eggs and meat of turtles are of economic importance as a food source. The once highly fashionable "tortoiseshell" of the hawksbill turtle, *Eretmochelys imbricata,* is still in demand, even with the expanding use of plastics. Aquatic turtles are often significant scavengers in lakes. In addition, a major pet trade has thrived on the sale of baby turtles of a dozen species although sales have greatly diminished in recent years because of the discovery of transmissible *Salmonella* disease in many of the specimens.

More than 30 species of turtles are officially recognized as in potential danger of extinction. The sea turtles' plight is particularly severe. Hunting, egg collecting, nest destruction, and habitat change are the primary threats to most species.

Taxonomy and Classification

Because there are no native land turtles in Britain, the British traditionally refer only to the sea turtles as *turtles,* and to all other members of this reptile group as *tortoises,* even if the latter are aquatic forms. In the United States, *turtle* refers to all members of the order Chelonia, whereas *tortoise* refers only to the land-dwelling forms. *Terrapin,* derived from an American Indian word, commonly refers to the diamond-back terrapin, *Malaclemys terrapin,* a brackish-water inhabitant of the U.S. Atlantic and Gulf coasts.

The approximately 250 living species of turtles are assigned to one of two suborders.

Pleurodira. The side-necked turtles, suborder Pleurodira, withdraw their heads into their shells by a sideways bending of the neck. This suborder contains 2 families, 4 genera, and about 50 species. They are restricted predominantly to the Southern Hemisphere.

Cryptodira. The suborder Cryptodira, whose members withdraw their heads into their shells by a vertical bending of the neck into an S-shaped curve, consists of about 12 families, 60 genera, and 200 species. Familiar U.S.

species include the common snappers, *Chelydra*, found throughout eastern North America and into northern South America, and alligator snappers, *Macroclemys*, which are confined to southeastern North America.

More than one-third of the world's turtle species are in the family Emydidae. Most emydids are at least partially aquatic, but the North American box turtle, *Terrapene*, is terrestrial. The soft-shell turtles, family Trionychidae, are almost exclusively aquatic.

The high-domed terrestrial TORTOISES have become almost legendary because of the famous giants of the Galápagos Islands, but desert regions are also successfully occupied by these tortoises. The SEA TURTLES are adapted to their marine environment by their generally large size, expert swimming abilities, and the physiological capacity to excrete salt through the lacrimal glands around their eyes.

Tuscaloosa [tuhs-kuh-loos'-uh] Tuscaloosa is the seat of Tuscaloosa County in western Alabama on the Black Warrior River; it has a population of 77,759 (1990). The city's industries, which produce paper, fabricated metal products, chemicals, tires, and lumber, are based on its nearby coal, iron, and timber resources. Tuscaloosa is also a distribution center for cotton grown in the surrounding farmlands. The University of Alabama (1831) is in the city.

Tuscaloosa was settled in 1809 by Creek Indians, but after its destruction in an 1813 battle between the Creek and U.S. troops, the town was resettled in 1816 by white planters. Tuscaloosa served as state capital from 1826 to 1846.

Tuscany [tuhs'-kuh-nee] Tuscany (Italian: Toscana), a region in west central Italy with an area of 22,992 km^2 (8,877 mi^2), is bounded by the Tyrrhenian and Ligurian seas to the west and the regions of Emilia-Romagna to the north, the Marche and Umbria to the east, and Rome to the south. With its capital at FLORENCE, and comprising the provinces of Arezzo, Florence, Grossetto, Livorno, Lucca, Massa-Carrara, Pisa, Pistoia, and Siena, as well as ELBA and other islands in the Tuscan Archipelago, the region has a population of 3,565,240 (1990 est.).

In spite of an often hilly or mountainous terrain with extensive mineral deposits (notably Carrara marble), Tuscany produces a wide array of agricultural products. Tuscan manufactures include ships, textiles, chemicals, and steel. Tourists come to see the region's striking countryside and medieval and Renaissance towns and cities.

Successively ruled by Etruscans, Romans (4th century BC–6th century AD), Lombards (6th–8th centuries), and Franks (8th–12th centuries), Tuscany began in the 11th century to break up into numerous free communes. During the 14th through 16th centuries, however, Florence progressively brought the region's city-states under its domination, and in 1569 the MEDICI rulers of Florence were created grand dukes of Tuscany. In 1737 the grand duchy passed to the house of Habsburg-Lorraine, in whose possession it remained (except for a period of French rule, 1799–1814) until joining united Italy in 1860.

Tuscarora [tuhs-kuh-rohr'-uh] The Tuscarora, an Iroquoian-speaking tribe of North American Indians, lived in numerous villages along the rivers of present-day North Carolina during the 17th century. They were hunters, farmers, fishers, and avid traders; in 1600 they numbered an estimated 5,000. As English settlers encroached on Indian territory, the Tuscarora, seeking peace, sent a statement of their grievances and eight wampum belts to the governor of Pennsylvania. His response was negative. Accordingly the belts were sent to the Five Nations Iroquois League, urging them to protect the Tuscarora.

After an unannounced expedition by white settlers through Tuscarora lands, the Indians, on Sept. 22, 1711, killed 130 colonists and began the Tuscarora War (1711–13). With help from Virginia and South Carolina, the North Carolinians defeated the Tuscarora. The Iroquois then honored the wampum belts and invited the Tuscarora north. They settled in northern Pennsylvania and New York and in 1722 became the sixth nation of the Iroquois League. After the American Revolution those Tuscarora who had sided with the British fled to Canada. In 1797 the American Tuscarora were granted a reservation in Niagara County, N.Y. The Tuscarora now number about 660 (1987 est.).

Tuskegee University [tuhs-kee'-gee] Established in 1881 by Booker T. WASHINGTON as a training school for African-American teachers, Tuskegee University is now a private coeducational university and technical institute in Tuskegee, Ala. Among the schools that offer both bachelor's and master's degrees are those of arts and sciences; engineering and architecture; education; agriculture and home economics; and veterinary medicine, which also offers a D.V.M.

Tussaud, Madame [too-soh'] The noted wax modeler and museum proprietress Madame Tussaud was born Marie Grosholtz in Switzerland on Dec. 7, 1761. After learning her craft from her uncle, a Parisian waxworker, she was imprisoned during France's Reign of Terror but escaped the guillotine by making death masks from the severed heads of its victims. In 1802, after separating from her husband, Madame Tussaud left for England. With her collection of modeled likenesses, she toured the country until 1835 when she established her famous wax museum in London, which she managed until her death, on Apr. 15, 1850. The museum's collection of historical figures, which reflects its founder's interest in the macabre, was partially destroyed by fire in 1925; restored in 1928, it remains a tourist attraction.

Tutankhamen, King of Egypt [toot-ahng-kah'-men] Tutankhamen, a pharaoh (r. 1361–1352 BC) of

The gold funerary mask of the Egyptian pharaoh Tutankhamen is one of thousands of opulent art objects found in the king's tomb at Thebes. Tutankhamen's burial chamber, discovered in 1922, proved to be a magnificent storehouse of ancient Egyptian artifacts. (Egyptian Museum, Cairo.)

the 18th dynasty, is one of the most famous Egyptian kings because his rich tomb survived comparatively intact for more than 3,000 years. The son-in-law of Akhenaten, he was only 9 years old when he succeeded his brother Smenkhkare (r. 1364–1361 BC), and for much of his reign Egypt was actually governed by his senior officials, especially by the vizier Ay. In his reign Akhenaten's monotheistic cult of Aten (Aton) was replaced with the traditional polytheistic religion; Tell el-Amarna, the monotheistic center, was abandoned and the capital returned to Thebes; and the cults of the state god Amen (Amon) and other gods were revived. The king himself changed his name from *Tutankhaten* ("living image of Aten") to *Tutankhamen* ("living image of Amen"). Tutankhamen died at the age of 18 and was succeeded by Ay (r. 1352–1348), who married Tutankhamen's widow and appropriated the king's tomb for himself. Although all the other tombs in the Valley of the Kings at Thebes were later plundered, the tomb in which Tutankhamen was ultimately buried was hidden by rock chips dumped from cutting the tomb of a later king. In 1922, Howard Carter discovered the tomb, which was filled with extraordinary treasure, including a solid gold coffin, a gold mask, jewelry, and other artifacts.

Tutsi [toot'-see] The Nilotic Tutsi, or Watutsi, are a central African people who constitute about 15% of the population of Rwanda and Burundi, to which they came, probably from Ethiopia, in the 1500s. The Tutsi are a gigantic people, often 2.1 m (7 ft) tall. They, the region's Bantu Hutu majority, and the Pygmy Twa are considered by some to be castes of a single ethnic group, sharing a common language, Kinyarwanda (Kirundi), and cultural traditions.

Traditionally, the Tutsi aristocracy kept cattle and extracted agricultural tribute from Hutu peasant cultivars in exchange for protection and the use of Tutsi cattle. Cleavages between Tutsi and Hutu were exacerbated under colonial rule, and the Hutu overthrew the Tutsi monarchy in Rwanda in 1959. Some 2 million Rwandan Tutsi refugees remain in exile. In Burundi, where Tutsi remain dominant, there have been periodic clashes between the two groups.

Tutu, Desmond In 1984 the Rt. Rev. Desmond Mpilo Tutu, b. Oct. 7, 1931, an Anglican bishop, became the second South African opponent of APARTHEID to be awarded the Nobel Peace Prize (after Albert John Luthuli in 1960). Tutu served as Anglican dean of Johannesburg (1975–76) and bishop of Lesotho (1976–78) before becoming (1979) the first black general-secretary of the South African Council of Churches. In 1984 he was elected the first black bishop of Johannesburg, and in 1986 he was elected archbishop of Cape Town, thus becoming titular head of the Anglican church in South Africa. An advocate of nonviolence, Tutu has called for outside economic pressure to force South Africa's white authorities to end apartheid.

Tutuola, Amos [too-too-oh'-luh] Amos Tutuola, b. Abeokuta, Nigeria, June 1920, was the first African writer to achieve international fame. Although his native language is Yoruba and his formal education never extended beyond elementary school, he has written all his novels in English. His first novel, *The Palm-Wine Drinkard* (1952), is a romance built out of elements from Yoruba folklore and mythology. Tutuola's other novels include *Simbi and the Satyr of the Dark Jungle* (1955), *Feather Woman of the Jungle* (1962), *Ajaiyi and His Inherited Poverty* (1967), *The Witch Herbalist of the Remote Town* (1980), and *The Wild Hunter in the Bush of the Ghosts* (2d ed., 1989).

Tuva [too'-vuh] Tuva, an autonomous region of the Russian republic, in the USSR, adjoins Mongolia in central Siberia. It has an area of about 170,500 km^2 (65,800 mi^2) and a population of 309,000 (1989). The capital is Kyzyl. Most inhabitants are Tuvan, a Mongoloid people speaking a northeast Turkic branch of the Ural-Altaic languages. The Mongol-dominated Tuvan have been a conquered people for almost all of their history. Traditionally nomads, lowland Tuvan herded horses, cattle, and sheep; on higher ground they raised camels, yaks, and reindeer. The economy today is based on pastoral farming, lumbering, and mining. Part of China from 1757 until 1911, the region became an independent republic, Tannu Tuva, in 1921. It was incorporated into the USSR in 1944 and became an autonomous republic in 1961.

AT A GLANCE

TUVALU

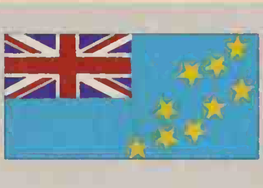
Land: Area: 26 km^2 (10 mi^2). Capital: Funafuti atoll (1985 pop., 2,810).

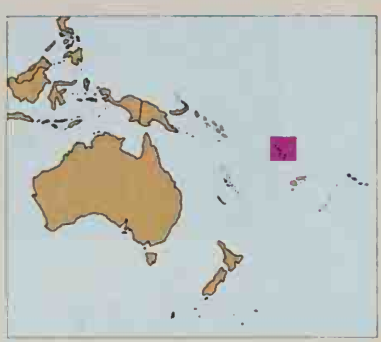
People: Population (1990 est.): 9,136. Density: 332 persons per km^2 (914 per mi^2). Distribution (1985): 34% urban, 66% rural. Official language: English. Major religion: Protestantism.

Government: Type: constitutional monarchy. Legislature: Parliament. Political subdivisions: none.

Economy: GNP (1989 est.): $4.6 million; $530 per capita. Labor distribution (1979): industry—12%; fishing—22%; government and services—50%. Foreign trade (1983 est.): imports—$2.8 million; exports—$1.0 million. Currency: 1 Australian dollar = 100 cents.

Education and Health: Literacy (1983): 95.5% of adult population. Universities (1991): none. Hospital beds (1987): 36. Physicians (1986): 3. Life expectancy (1990): women—63; men—60. Infant mortality (1990): 33 per 1,000 live births.





Tuvalu [too-vuh-loo'] Tuvalu, formerly known as the Ellice Islands, is an independent state in the Commonwealth of Nations. The nine-island cluster is located in the Pacific Ocean just south of Kiribati (formerly the Gilbert Islands) near the intersection of the equator and the international date line. Tuvalu's population is principally Polynesian. The capital is Funafuti atoll. The economy is based on subsistence agriculture and fishing, and a small amount of copra is exported. Population growth has severely strained Tuvalu's limited resources; remittances from Tuvaluans working abroad, revenues from a unique trust fund established by aid donors in 1987, foreign aid, and the sale of postage stamps provide income.

According to tradition, Tuvalu was first settled by Samoans and Tongans. Visited by the Spanish navigator Alvaro de Mendaña in 1568, the islands became a British protectorate in 1892 and part of the Gilbert and Ellice Islands Colony in 1916. They became a separate self-governing colony in 1975 and gained independence in 1978. In 1983 the United States formally renounced its claim to four Tuvaluan islands.

Tuxtla Gutiérrez [toos'-tlah goot-yay'-rays] Tuxtla Gutiérrez (1983 est. pop., 166,476), the capital of Chiapas state, is in southeastern Mexico. A commercial center located on the Pan American Highway, the city has industries that process locally grown coffee, tobacco, cotton, and corn. The Maya ruins of BONAMPAK are nearby. Originally an Indian settlement, it was first visited by Spaniards in 1546.

Twachtman, John Henry [twahk'-muhn] John Henry Twachtman, b. Cincinnati, Ohio, Aug. 4, 1853, d. Aug. 8, 1902, was a founding member of The Ten, a group of American painters who drew from both impressionism and the tonalism of James McNeill Whistler to create a variety of highly individual styles. Twachtman attended the Royal Academy in Munich and studied in Paris. By 1885 he had developed his distinctive, lyrical approach to landscape in which forms abstracted from nature are painted in subtle but strongly brushed colors, as in *Snowbound* (c.1890–1900; Art Institute of Chicago).

Twain, Mark Mark Twain was the pseudonym of Samuel Langhorne Clemens, b. Florida, Mo., Nov. 30, 1835, d. Apr. 21, 1910, who achieved worldwide fame during his lifetime as an author, lecturer, satirist, and humorist. Since his death his literary stature has further increased, with such writers as Ernest Hemingway and William Faulkner declaring his works a major influence on 20th-century American fiction.

Twain was raised in Hannibal, Mo., on the Mississippi River. Apprenticed first to a printer, he soon joined his brother Orion's *Hannibal Journal*, supplying copy and becoming familiar with much of the frontier humor of the time. From 1853 to 1857, Twain visited New York, Phila-

Mark Twain, who was immensely popular during his lifetime as a humorous writer and lecturer, is often heralded as the first fiction writer to achieve a uniquely American voice. His insight into character, ironic humor, and use of the vernacular have placed such works as Adventures of Huckleberry Finn *(1884) and* A Connecticut Yankee in King Arthur's Court *(1889) among the best-loved works of American fiction.*

delphia, St. Louis, and Cincinnati, corresponding with his brother's newspapers under various pseudonyms. After a visit to New Orleans in 1857, he learned the difficult art of steamboat piloting, an occupation that he followed until the Civil War closed the river and that furnished the background for "Old Times on the Mississippi" (1875), later included in the expanded *Life on the Mississippi* (1883).

In 1861, Twain traveled to Carson City, Nev., with his brother Orion, who had been appointed territorial secretary. After unsuccessful attempts at mining, he became a correspondent for the *Virginia City Territorial Enterprise.* At first he signed his sketches "Josh," but early in 1863 he adopted the name Mark Twain, borrowed from the Mississippi leadsman's call meaning "two fathoms" deep.

Twain went to San Francisco in 1864. Dubbed the "Wild Humorist of the Pacific Slope," he achieved a measure of national fame with his story "The Celebrated Jumping Frog of Calaveras County" (1865). In 1867 he traveled to the Mediterranean and the Holy Land, providing letters to the *San Francisco Alta California* that, in their revised form as *The Innocents Abroad* (1869), won international attention.

In 1870, Twain married Olivia Langdon of Elmira, N.Y. After serving briefly as editor and part owner of the *Buffalo Express*, he moved to Hartford, Conn., in 1871, abandoning journalism in order to devote his full attention to serious literature. There, and during summers in Elmira, he produced *Roughing It* (1872), an account of his Western years; *The Gilded Age* (1873, with Charles Dudley Warner), a satire of get-rich-quick schemes and political chicanery; the new pieces for *Sketches, New and Old* (1875); and TOM SAWYER (1875), his classic tale of boyhood.

A European sojourn in 1878–79 inspired *A Tramp Abroad* (1880), soon followed by *The Prince and the Pauper* (1882), Twain's first historical novel. He later turned to history again in the allegorical satire *A Connecticut Yankee in King Arthur's Court* (1889), his most powerful fictional indictment of political and social injustice. Meanwhile, he completed *Life on the Mississippi* (1883) and, after establishing his own firm, Charles L. Webster and Co., published his masterpiece, HUCKLEBERRY FINN, in 1884.

Increasing financial problems prompted Twain to move to Europe in 1891, just after finishing *The American Claimant* (1892). In 1894, following the failure of his publishing company and of the Paige typesetting machine in which he had invested heavily, Twain had to declare bankruptcy. During this period he turned out a number of works: *The Tragedy of Pudd'nhead Wilson* (1894), *Tom Sawyer Abroad* (1894), *Personal Recollections of Joan of Arc* (1896), and *Tom Sawyer, Detective* (1896). In 1895 he embarked on a world lecture tour, later described in *Following the Equator* (1897).

Additional stress came with the deaths of Twain's daughter Susy in 1896 and of his wife in 1904. His writings of the late 1890s and 1900s became more pessimistic than ever; "The Man That Corrupted Hadleyburg" (1898) and *What Is Man?* (1906) are particularly scathing. Recent volumes in the Mark Twain Papers series—*Which Was the Dream?, and Other Symbolic Writings of the Later Years* (1967), *Mark Twain's Mysterious Stranger Manuscripts* (1969), and *Mark Twain's Fables of Man* (1972)—suggest, however, that the period was not the wasteland described by some critics.

tweed Tweed is a somewhat hairy, textured woolen fabric originally hand-woven by country people who lived near the River Tweed between England and Scotland. It is now often spun and woven by machine, but Harris tweed, exported from the islands of the Outer Hebrides off the northern coast of Scotland, is still hand-woven. Vegetable dyes are used for the wool yarns and, in the best tweeds, produce the muted, subtle colors that give the fabric its distinctive look. Tweed patterns are usually traditional twills, checks, and herringbones.

Tweed, River The River Tweed rises in the southern uplands of Scotland and flows for 156 km (97 mi), entering the North Sea near Berwick-on-Tweed, England. For 27 km (17 mi) it follows the Scottish-English border. Tweed cloth is a major product of the river-valley communities.

Tweed, William M. William Marcy (or Magear) Tweed, b. New York City, Apr. 3, 1823, d. Apr. 12, 1878, was the corrupt Democratic boss of New York City in the 1860s. In the early 1850s he became foreman of a volunteer fire company, which he allied with TAMMANY HALL; he also served as an alderman (1851–55) and U.S. representative (1853–55). In 1856 he became a member of the county board of supervisors and a school commissioner. Over the next five years Tweed and his allies won many key city and county offices; by the end of 1861 they thoroughly dominated both Tammany Hall and local government.

In 1868, Tweed became a state senator; John T. Hoffman, a protégé of his, was elected governor in 1869. Tweed's ring began applying its methods to state politics. Penniless in 1861, Tweed had acquired a fortune of at least $2.5 million by 1871, largely through influence peddling and kickbacks from the sale of city contracts and franchises. Altogether the ring stole from $40 million to $200 million of public funds.

Revelations in 1870 regarding the ring's thievery and the formation (1871) of a citizens' committee headed by Samuel J. TILDEN led in 1873 to Tweed's conviction for fraud. Escaping custody, in 1875, Tweed fled to Spain. Recognized in 1876 through a Thomas Nast cartoon, he was returned to New York, where he died in jail.

12th Amendment see CONSTITUTION OF THE UNITED STATES

twelve-tone system see SERIAL MUSIC

20th Amendment see CONSTITUTION OF THE UNITED STATES

25th Amendment see CONSTITUTION OF THE UNITED STATES; VICE-PRESIDENT OF THE UNITED STATES

21st Amendment see CONSTITUTION OF THE UNITED STATES

24th Amendment see CONSTITUTION OF THE UNITED STATES

twenty-one see BLACKJACK

22d Amendment see CONSTITUTION OF THE UNITED STATES

26th Amendment see CONSTITUTION OF THE UNITED STATES

23d Amendment see CONSTITUTION OF THE UNITED STATES

Twenty Thousand Leagues Under the Sea
Twenty Thousand Leagues Under the Sea (1870), a futuristic adventure novel by Jules VERNE, was one of the most successful early attempts to exploit the growing contemporary interest in science. It demonstrated Verne's genius for using his own scientific interests and prophetic talents to produce exciting and occasionally didactic romantic science fiction. The story describes the adventures of Professor Aronnax (the narrator), Conseil (his servant), and Ned (a harpoonist), on board the submarine *Nautilus*, commanded by the mysterious and vengeful Captain Nemo.

two-body problem A classic physics problem is that of describing the resultant motion of two objects when they are subjected only to their mutually attractive force. The theoretical problem was completely solved by Isaac Newton and published in his *Principia Mathematica* (book 3, 1687). The motion is called Keplerian motion because it was summarized by Johannes Kepler before Newton; in fact, Newton could have derived the law of gravitation from KEPLER'S LAWS. For the case of two astronomical bodies, which are mutually attracted by gravitation, Newton showed that the motion is confined to a plane and that the motion of one body with regard to the other follows a curve of the various CONIC SECTIONS, that is, either an ellipse (of which a circle is a special case), a parabola, or a hyperbola. Electrically charged particles, which also obey an inverse square law of attraction (or repulsion) similar to gravitation, also have conic-section motions.

This solution, however, has only limited application in practice because of the presence of other bodies. The determination of the motion of the Earth-Moon system, for example, requires the inclusion of the effects caused by the Sun, the planets Jupiter and Saturn, the equatorial bulge of the Earth, and even the effects of the Earth's tides. The problem of exactly determining the relative motions of three bodies has not yet been solved.

See also: THREE-BODY PROBLEM.

Two Sicilies, Kingdom of the The Two Sicilies was a name intermittently used for the kingdoms of Sicily and Naples when the two were jointly ruled. First used (1443) by ALFONSO V, king of Aragon, Sicily, and Naples, it was an official name from 1815 to 1861.

Tworkov, Jack [twohr'-kawv] First recognized in the 1950s as an exponent of the abstract expressionism of the New York school, the American painter Jack Tworkov, b. Biala, Poland, Aug. 15, 1900, d. Sept. 4, 1982, began working in a new geometric style during the 1960s. His brightly colored abstract works involve a type of gestural, calligraphic brushwork that creates exciting tensions. Rigidly geometric compositions based on a grid structure are softened by an overlay of muted, toned brushwork reminiscent of his earlier work. Shapes often seem to project or recede, creating a strong sense of movement.

Tyler, Anne The American novelist and short-story writer Anne Tyler, b. Minneapolis, Minn., Oct. 25, 1941, writes mainly of life in small Southern towns, although her themes concern the human condition in general. From her first novel, *If Morning Ever Comes* (1964), to *Dinner at the Homesick Restaurant* (1982) and *The Accidental Tourist* (1985; film, 1988), she has observed human isolation and rescued those of her characters with the innate courage to overcome it. Tyler reveals her people through dialogue and through the arbitrary clutter and detail of their lives. *Breathing Lessons* (1988) won the Pulitzer Prize for fiction.

AT A GLANCE

JOHN TYLER
10th President of the United States (1841–45)

Nicknames: "Accidental President"; "His Accidency"

Born: Mar. 29, 1790, Charles City County, Va.

Education: College of William and Mary (graduated 1807)

Profession: Lawyer

Religious Affiliation: Episcopalian

Marriages: Mar. 29, 1813, to Letitia Christian (1790–1842); June 26, 1844, to Julia Gardiner (1820–89)

Children: Mary Tyler (1815–48); Robert Tyler (1816–77); John Tyler (1819–96): Letitia Tyler (1821–1907); Elizabeth Tyler (1823–50); Anne Contesse Tyler (1825); Alice Tyler (1827–54);Tazewell Tyler (1830–74); David Gardiner Tyler (1846–1927); John Alexander Tyler (1848–83); Julia Gardiner Tyler (1849–71); Lachlan Tyler (1851–1902); Lyon Gardiner Tyler (1853–1935); Robert Fitzwalter Tyler (1856–1927); Pearl Tyler (1860–1947)

Political Affiliation: Democrat, Whig

Died: Jan. 18, 1862, Richmond, Va.

Buried: Hollywood Cemetery, Richmond, Va.

Vice-President: None

John Tyler

Tyler, John The tenth president of the United States (1841–45), John Tyler was the first to succeed to office on the death of an incumbent president. Born in Charles City County, Va., on Mar. 29, 1790, he graduated from the College of William and Mary in 1807. He then studied law and in 1811, at the age of 21, was elected to the Virginia legislature.

Early Political Career. Throughout his career Tyler displayed a political independence and a commitment to state rights that was tenacious even by Virginia standards. He upheld the view that federal powers must be limited to those specified in the Constitution and consistently opposed the idea of a national bank with state branches, seeing this as an unwarranted federal infringement on the constitutional rights of the states. Serving in the U.S. House of Representatives (1817–21), he rejected the national economic program advocated by Henry Clay and John C. Calhoun, voting against protective tariffs, federal aid for internal improvements, and the successful bill to charter a second Bank of the United States. Tyler also opposed the Missouri Compromise of 1820 as an unconstitutional limitation of the rights of slaveholders. Retiring from Congress in 1821, he served as Virginia's governor (1825–27).

Tyler returned to Washington in 1827 as a senator, supporting parties and measures by the standard of their fidelity to his strict constitutional views. He endorsed Andrew Jackson's presidential candidacy and supported Jackson's stand against internal improvements and the second Bank of the United States. Tyler opposed the tariffs of 1828 and 1832 but condemned South Carolina's nullification of those laws in 1832. He also, however, opposed the Jackson-sponsored Force Bill of 1833 authorizing the use of military force to suppress nullification—Tyler cast the only Senate vote against the measure. In 1834 he censured the president's removal of federal funds from the National Bank. In February 1836 the Jacksonian-controlled Virginia legislature instructed Tyler to vote to expunge the Senate censure resolution against the president on this matter. He refused, resigned his seat, and severed his Democratic party ties.

In 1839 the Whig party chose Westerner William Henry Harrison as its presidential candidate and unanimously nominated Tyler as vice-president to balance the ticket. The party issued no platform and won the 1840 race with mass rallies, songs, and slogans such as "Tippecanoe and Tyler, too."

Presidency. The 69-year-old Harrison died after a month as president, and on Apr. 6, 1841, Tyler took the oath of office. His constitutional scruples, however, placed him on a collision course with the nationalist-minded Whig congressional caucus and its leader, Henry Clay. Tyler vetoed two Whig bills to create a new national bank. In retaliation, the Whig cabinet—with the exception of Secretary of State Daniel Webster—resigned in September 1841, and soon after the caucus expelled the president from his party. In 1845, Tyler became the first president to have Congress override his veto.

Tyler's greatest successes came in foreign policy. He supported Webster in negotiating the WEBSTER-ASHBURTON TREATY (1842), which settled the Maine boundary dispute. He ended the Seminole War, extended the Monroe Doctrine to Hawaii, and opened the first American trade mission to China.

After Webster resigned in May 1843, Tyler vigorously pursued the annexation of the slaveholding Republic of Texas. To avoid the delicate slavery issue, both parties had carefully sidestepped the Texas question. Politically independent, Tyler negotiated a treaty with Texas. Although the Senate rejected the treaty in June 1844, Tyler had forced the issue of annexation into national politics. A man without a party, he did not run for reelection in 1844, but Democrat James K. Polk won the presidency (over Henry Clay) on an annexationist platform, and in March 1845, Tyler signed a joint resolution of Congress annexing Texas.

In his later years, Tyler served in the provisional Confederate Congress in 1861 and was elected to the Confederate House of Representatives. He died before he could take office.

Tylor, Sir Edward B. Sir Edward Burnett Tylor, b. Oct. 2, 1832, d. Jan. 2, 1917, is considered the founder of anthropology in Great Britain. He is known for his research on culture, cultural evolution, and the origin and development of religion. Tylor was born into a well-to-do British Quaker family. When he was 24 years of age, concern for his health led him to travel to the United States, and while on a crowded omnibus in Havana he chanced to meet a virtuoso traveler, Henry Christy. The two went to Mexico, and by then Tylor's fascination with ethnology and archaeology had taken permanent hold. He returned to Great Britain and soon published his first book, *Anahuac: Mexico and the Mexicans, Ancient and Modern* (1861).

In developing his view of progressive cultural evolution, Tylor held that earlier stages of development could be known by what he termed *survivals*, ancient traits that lingered on in more advanced cultures. Also noteworthy is Tylor's theory of ANIMISM, that primitive religions endow natural objects with a soul. Tylor became keeper of the University Museum at Oxford in 1883. His major works include *Primitive Culture* (1871) and *Anthropology* (1881).

tympanum see ROMANESQUE ART AND ARCHITECTURE; SCULPTURE

Tynan, Kenneth [ty'-nuhn] The British drama critic Kenneth Tynan, b. Apr. 2, 1927, d. July 26, 1980, was celebrated for his acerbic, witty reviews and for his interest in drama as a medium of social criticism. During the 1950s he was drama critic of the *Evening Standard*, the *Observer*, and the *New Yorker* and from 1963 to 1973 served as literary manager of the National Theatre, London. Tynan's satirical revue *Oh! Calcutta!* (1969) ran for many years on Broadway. A collection of his biographical sketches, *Show People*, was published in 1980.

Tyndale, William [tin'-duhl] William Tyndale, b. *c.*1494, d. Oct. 6, 1536, was an early English Protestant reformer most famous for his English translation of the Bible. He printed his translation of the New Testament in Germany in 1526. When copies arrived in England, the work was denounced by the church hierarchy and others, such as Sir Thomas More, who demanded his death as a heretic. Thereafter, Tyndale lived most of the time in Antwerp, where he revised his New Testament and printed translations of the Pentateuch and of Jonah. He also wrote Protestant tracts. Unlike earlier English translators, he was a master of Greek and Hebrew and was able to benefit from Erasmus's Greek version of the New Testament.

In 1535, Tyndale was arrested and imprisoned at Vilvorde, near Brussels. He was condemned for heresy and executed.

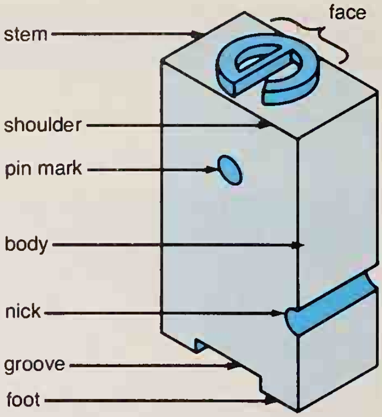
type and typesetting In PRINTING, *type* is the term used to describe the full range of alphabetic and numeric characters and punctuation marks necessary for the composition of text. Typesetting is the craft of arranging type—either by hand or machine—into readable form. Typography involves the choice of type and the design of pages for a book or other printed piece.

Typefounding and Hand Setting

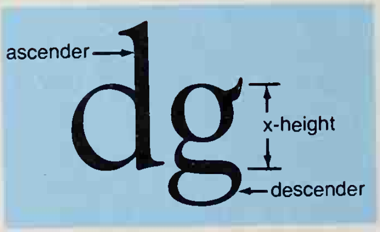
The German Johann Gutenberg is credited with developing the first successful technology for the rapid and accurate manufacture of type, a process known as typefounding. In Gutenberg's method, invented about the middle of the 15th century, a character was engraved in relief on the end of a hard metal punch, which was then driven into a softer piece of metal known as a matrix. The matrix was placed in an adjustable type mold, and molten metal was poured into the mold, hardening almost instantaneously.

Type terminology, dating from the days when all type was set by hand and printed almost exclusively by LET-

A piece of modern movable type differs little from the type used by Johann Gutenberg. Type is made of an alloy of lead, antimony, and tin and cast as a rectangular block. The letter to be printed is raised and is known as the face. The nick, groove, and pin mark on the body of the type help align it on a composing stick during the process of typesetting.



The length of lowercase type is given in terms of the x-height, the ascender, and the descender. The total length of the type from ascender to descender determines the point size.



TERPRESS, remains the same. A font of type comprises all the uppercase and lowercase letters of the alphabet (the term *case* derives from the printer's case, a hinged double box in which all the capital letters are kept in the upper case), as well as numbers, punctuation marks, and special characters in a particular design and size. Points constitute an important category of size. One point is equivalent to 0.01383 inches (0.35128 mm), and all type is designated in point size. There are 12 points to a pica, and approximately 72 points to the inch (25.4 mm).

To set type the compositor uses a composing stick that is calibrated in picas and adjusted to whatever line length is specified in the typographer's design. Divisions between words and sentences are made with assorted metal space units; the widths of these spaces are based on the em, a unit of measurement that is a square of the typeface's point size: that is, a 10-point em is 10 points wide and 10 points high. One-half of an em is an en. When space is needed between lines of composed type, thin strips of metal called leads (2 points thick) or slugs (6 points thick) are inserted.

When the compositor nears the end of the line, he inserts spacing material between the words to make the line of type fit tightly, a process called justification. When the composing stick is full of lines, the justified type is removed and laid on metal galley trays. The lines of type are "leaded out" on the galleys, and proofs—single sheets printed by hand—are pulled and corrections made. Then pages are made up. After page proofs have been made and approved, the type is locked into a form and made ready for printing.

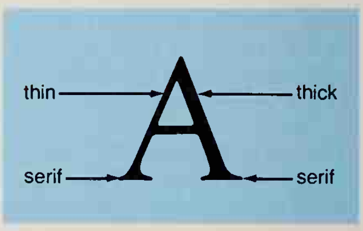
The Development of Typefaces

Early typeface designs were based on the pen-drawn letters of the scribes who, before Gutenberg, had produced books by hand. Gutenberg's typefaces were modeled on the formal black-letter styles popular in Germany at the time. As the art of printing spread, less formal black-letter type designs made their appearance. The scribal hands favored in Italy by humanist scholars were of an entirely different nature. Type designers made faithful copies of these Italian humanist scripts in metal, variations of which are used to this day and are called "romans." Influential early roman faces were designed in Venice by the French printer Nicolas Jenson during the 1470s. Aldus MANUTIUS, a Venetian printer, also designed a celebrated roman and was the first to introduce (1501) an italic typeface, which was based on Italian cursive hand.

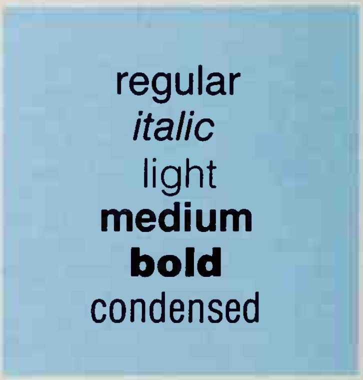
By the middle of the 16th century, type designers had begun to integrate Renaissance ideals of proportion into their types, many of which were formed according to geometric principles. An increasing French design influence was obvious in the work of Claude Garamond and Robert Granjon. French types dominated book printing throughout Europe for over 100 years, finally giving way in the 17th century to the fresh but somewhat crude types of Dutch foundries. The sturdy vigor of these types particularly appealed to English printers who imported them in large quantities. In the 1720s, however, the great English typefounder William CASLON issued his first types. Though they showed an unmistakable Dutch influence, his designs were less harsh and quite readable, soon becoming great favorites with printers.

The typefaces discussed so far are classified by histori-

A modern roman typeface is characterized by thin and thick lines as well as by the presence of serifs—short-stroke lines at the base of the letter.



Type families, such as the Helvetica typefaces illustrated, have in common the absence or presence of serifs and the thickness of lines in a letter. Within families type can vary from regular, perpendicular letters to slanted, italic letters and can range from light to bold and also to condensed letters.



ans as old-style romans. So-called transitional faces began to appear in the 18th century, characterized by increased contrast between thick and thin lines, lighter serifs, and a strong vertical stress. (A serif is the short, angled line at the ends of a letter's upper and lower strokes.) The types of the English printer John BASKERVILLE, first used in 1757, are often described as the first true transitionals.

Toward the end of the 18th century, neoclassical, or modern romans, began to appear, marked by thin, graceful serifs, their most significant feature. The types of Parisian printer-founder Firmin Didot and his counterpart in Italy, Giambattista BODONI, were prototypical examples of the style.

Among the more important developments in the 19th century were the introduction of square-serif designs in 1815 by the English founder Vincent Figgins and, a year later, the first sans-serif—a type without serif strokes—by William Caslon IV. All-capital, heavily weighted, square-serif (known also as slab serif) designs were rugged types that became popular with printers handling advertising. With the incorporation of a lowercase alphabet, square serifs evolved by mid-century into a popular family of types known as Clarendons.

By the end of the 19th century, the speed of printing presses had increased; the economies of the printing industry precluded typographical niceties. On the printed page, type looked weak and ineffectual. By way of protest, in 1888 the English craftsman William MORRIS designed a typeface based on 15th-century Jensonian models. Called Golden, it influenced the type designs of other private presses, as well as attracting the attention of commercial foundries who admired its dense, old-style characteristics.

Twentieth-Century Developments in Typesetting

Throughout the 19th century, attempts were made to develop reliable mechanical typesetting machines. The chief defects of these early machines lay in their inability to provide automatic justification. With the invention of the LINOTYPE machine by Ottmar Mergenthaler during the 1880s, and later the development of the MONOTYPE, the mechanical problems were solved.

Like the earlier handcasting of type, both the linotype and the monotype used molten, or "hot," metal. The decline of letterpress relief printing and an increase in the use of offset spurred research into the development of composition systems dispensing with metal typecasting altogether. In 1946 an Intertype Fotosetter was tested at the U.S. Government Printing Office. The Fotosetter was a line-casting machine containing brass matrices that had film negatives of characters inserted into their sides. Light was focused through the negatives onto photosensitized paper and produced images of type from which printing plates could be made.

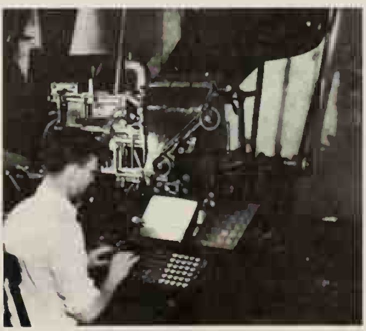
Second-generation phototypesetters made their debut in 1954 with the introduction of the Photon 200 machine. Here, a spinning film matrix contained all of the characters in a font, with a stroboscopic light source, and a system of lenses for focusing images of type in the desired sizes onto sensitized paper. The next generation of phototypesetters stored fonts digitally on a magnetic core. Typesetting code was sent to a character generator, which produced bright images on a cathode ray tube. These in turn were focused through lenses onto sensitized paper.

Fourth-generation systems have been introduced that feature digitally stored fonts and very-high-resolution laser-driven imaging devices.

Type as an Element in Book Design

The choice of an appropriate typeface is a crucial element in the design of a book. Conscientious typographers consider many factors before selecting a typeface, including length of text, type and quality of paper, the printing process to be used, and the subject of the book itself. Types that are weak or light in appearance are tiring to read when used as text faces, while bold or unusual faces call attention to themselves. Publications directed at a mass readership, like newspapers and magazines, require types of a special nature. During the late 19th and early 20th centuries, a number of so-called legibility faces were designed specifically for high-speed, high-quality printing applications. They had, typically, sturdy serifs and large x-heights (basical-

(Left) *In typsetting by hand, letters are placed one by one in a composing stick.* (Center) *Linotype uses a keyboard to assemble a line of matrices—metal blocks with engraved letters—on a spaceboard; the line is then cast, using molten type metal.* (Right) *In phototypesetting a cathode-ray tube (CRT) machine composes a text by computer; a video display terminal (VDT) is used to change copy before printing on film.*



ly, a measure of readability). Two celebrated types in this class are Century and Times Roman.

While the ideal text face should be readable and well-balanced, display types are meant to be visible.

See also: BOOK; PUBLISHING, DESKTOP.

typewriter A typewriter is a machine that can reproduce printed characters on paper. It has a keyboard containing the letters of the alphabet, numbers, common punctuation marks, and various controls.

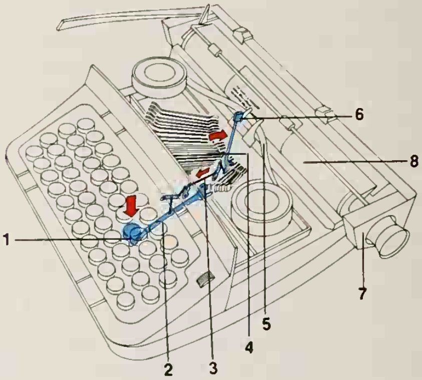
The first practical typewriter was developed by Christopher Latham Sholes and was patented in 1868. Six years later, Eliphalet Remington and Sons, a firm of gunsmiths, placed the first commercial typewriter on the market. This early model, called the Remington, had a cylinder, or carriage, to hold the paper, along with line-spacing and carriage-return mechanisms; a device called an escapement that moved the carriage after each letter was struck; type-holding rods arranged in a semicircle, so that when the keys were depressed each rod struck at the proper point on the paper; an inked ribbon against which the raised letters on the rods struck, transferring their images to the paper; and a keyboard similar to that of present-day typewriters.

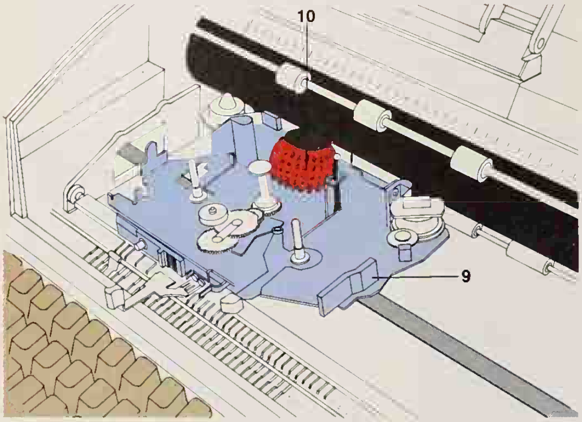
Electric typewriters, which power the operations of the machine with an electric motor, were introduced by 1920. In the 1920s, small portable typewriters became commercially successful.

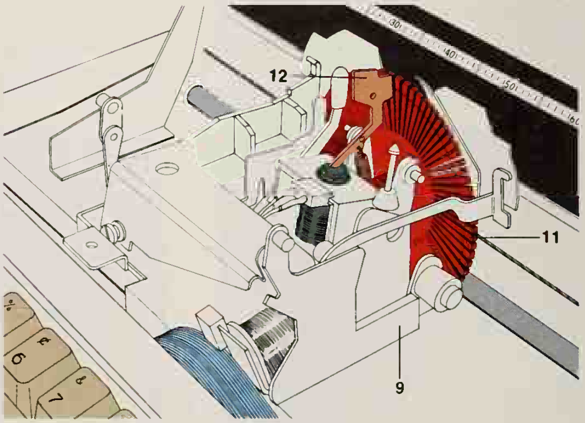
The first basic change in typewriter operation appeared in 1961: a machine that eliminated the letter rods, using instead a small, rotating ball with the type symbols covering it in relief. Instead of a moving carriage and stationary letters, this new typewriter used a stationary carriage over which the ball moved and printed with great speed. The ball has been replaced on newer typewriters by a daisy-wheel printer—a plastic disk about 10 cm (4 in) in diameter, with flexible spokes each of which ends in a character. The wheel rotates rapidly to bring a particular character into printing position, the spoke is struck against a carbon-backed plastic ribbon, and its impression appears on the paper. Both ball and wheel are made in a variety of typefaces and can easily be changed.

Electronic typewriters, which began to appear in the 1970s, approach WORD PROCESSORS in many of the things they are able to do: they can move text around, check spelling, store documents in a memory.

These three typewriters illustrate three basic ways of producing typewritten characters. (Right) *A manual typewriter operates through the pressure of fingers on the keys. When a key* (1) *is struck, a key lever* (2) *and linkage* (3) *force the end of the type bar* (4) *against the ink ribbon* (5), *and the raised typeslug* (6) *impresses its image on the paper. Other components include the movable carriage* (7) *and the platen* (8). *In both of the electrically powered machines seen below, the carriage is stationary; instead, the carrier* (9), *holding a type element and ink ribbon, moves along the platen.* (Below left) *The surface of the golf-ball element* (10) *is studded with raised characters. It rotates and tilts to press the appropriate character against the paper.* (Below right) *The daisy-wheel element* (11), *with type slugs at the ends of flexible strips, spins to place the proper strip where a hammer mechanism* (12) *strikes it against the paper.*







Despite the revolutionary advances in typewriter capabilities, the keyboard arrangement has remained unchanged since the first Remington. It was nicknamed QWERTY for the top line of letters. A much more efficient arrangement was devised in 1936 by August Dvořák. With the Dvořák keyboard, the right hand does equal work with the left, the strongest fingers do the most work, and 70% of the typing takes place on the "home row," where the fingers naturally rest.

typhoid fever [ty'-foid] A severe, generalized human disease, typhoid fever is caused by the bacterium *Salmonella typhi*, which enters the body in water or food contaminated with the feces or urine of a carrier of the disease. Chronic carriers—2% to 5% of patients who have recovered—are the main source of infection. After an incubation period of 7 to 21 days, the illness begins with fever, lethargy, headache, and loss of appetite. Increasing weakness and abdominal discomfort develop during the second week, when a rose-colored rash may appear. Intestinal bleeding or perforation may occur and can be fatal.

Treatment with chloramphenicol or ampicillin has reduced the mortality rate from 30% to 2%. In untreated patients, recovery may begin after about 4 weeks. In urban areas, transmission of typhoid fever may occur through food contaminated by polluted water or by food handlers who are carriers. Typhoid fever can be prevented by sanitary disposal of human excreta and by chlorination of drinking water. Injection of a vaccine prepared from killed typhoid bacilli affords moderate short-term protection from the disease.

typhoon see HURRICANE AND TYPHOON

typhus [ty'-fuhs] Typhus is any of several infectious diseases, each caused by a different rickettsial microorganism. Louse, or epidemic, typhus is the most serious form; the infectious organism, *Rickettsia prowazekii*, lives only in humans and in body lice. The louse's infected feces reach the human bloodstream through scratches in the skin or through the mucous membranes of the eye or the respiratory tract. The major symptoms are intractable headache, extensive skin rash, and high fever. The mortality rate is significant in untreated persons over 50 years of age. Antibiotic therapy is effective if started early. Louse typhus can be prevented through vaccination. Endemic murine typhus, or flea typhus, caused by *R. mooseri* and transmitted from rats to humans by fleas, is much milder.

Tyrannosaurus [tuh-ran'-uh-sohr'-uhs] The best known of all dinosaurs, *Tyrannosaurus* was the largest and the last of the meat-eaters, or carnosaurs. It is known from a few skeletons and numerous fossil fragments from the latest Cretaceous strata of western North America, about 65 million years old.

Tarbosaurus, *a close Asian relative of* Tyrannosaurus, *was a meat-eating dinosaur that lived about 70 million years ago. The fiercest and last of the carnivorous dinosaurs, it was 15 m (50 ft) long and 5.5 m (18 ft) high and had a huge head armed with dozens of sharp, flesh-tearing teeth.*

Tyrannosaurus walked on its hind legs and stood about 5.5 m (18 ft) high; its total length was almost 15 m (50 ft), and it may have exceeded 7.3 metric tons (8 U.S. tons) in weight. Its huge head, up to 1.5 m (5 ft) long, was carried on a short, sturdy neck. The jaws were long and powerful and bore dozens of curved, serrated teeth up to 20 cm (8 in) long. The massive hind legs, armed with large claws, were about 3 m (10 ft) in length. The front limbs were very small—only about 75 cm (30 in) long and have thus been generally described as useless. They each carried two sizable claws, nonetheless, and the large dimensions of their internal skeletal supports (the pectoral girdle) suggest the presence of strong muscles. Perhaps the forelimbs anchored the massive body and prevented forward slippage when *Tyrannosaurus* arose from a resting position. *Tyrannosaurus*'s long, heavy tail provided counterbalance for its front-heavy body. Its bulky body and heavy legs imply that *Tyrannosaurus* stalked its prey rather than pursued it, possibly scavenging as well. Either way, *Tyrannosaurus* was well designed for feeding on the other large dinosaurs.

Tyre [tyr] Tyre was a great trading port of ancient PHOENICIA, located on the Mediterranean Sea about 40 km (25 mi) south of Sidon. The city gave its name to the dye known as Tyrian purple. Today it survives as the small southern Lebanese town of Sur (1982 est. pop., 23,000).

Founded on an island, Tyre possessed one of the best harbors on the coast and was almost impregnable against siege until Alexander the Great reduced it in

332 BC by building a causeway that joined the island to the mainland.

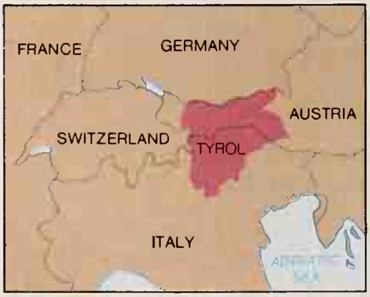
Tyre entered history as a vassal of the 18th dynasty of Egypt (1570–1320 BC). Following the disruption of Egypt and other Near Eastern powers in the age of the Sea Peoples, the city not only attained an independent position but seems to have dominated Sidon. During the 10th century BC, Tyre supplied cedars, carpenters, masons, and bronzesmiths for King David (r. *c.*1000–*c.*960 BC) and King Solomon (r. *c.*960–*c.*921 BC), and Tyrian sailors were available for Solomon's Red Sea fleet. Under Hiram (r. 969–936 BC) and earlier rulers Tyre developed trade with Cyprus and Spain and founded such colonies as Utica and Carthage.

Subject to Assyria during the 8th and 7th centuries BC, Tyre was dominated successively by the Persians (538–332 BC), Ptolemies, Seleucids, Romans, and Muslim Arabs (AD 638–1124). It was part of the Latin kingdom of Jerusalem in the 12th and 13th centuries but fell to the Mamelukes and was destroyed in 1291.

Tyrian purple [tir'-ee-uhn] Tyrian purple is a strong dye—ranging in color from blue to crimson—made from the crushed shells of certain mussels and whelks. The ancient Mediterranean cities of Sidon and Tyre were the focus of this dye industry, but some experts claim the dye was produced elsewhere as early as 1500 BC. Only a small portion of the shell could be used, making the dyed cloth very costly and limiting its use to the wealthy. Tyrian purple garments became a mark of the Roman aristocracy.

Tyrol [tir-ohl'] Tyrol is a historic region mainly corresponding to the western Austrian province of Tyrol and the northern Italian administrative region of Trentino-Alto Adige. The Alps dominate the area, with the highest peak, Wildspitze, reaching 3,774 m (12,382 ft). The economy is based on farming, mining, copper smelting, the pharmaceutical and chemical industries, and the production of hardware, textiles, glass, and skiing equipment. Tourism is important; the best-known resorts are Innsbruck, Kitzbühel, Seefeld, and the Ziller Valley.

Medieval Tyrol became a Habsburg possession in 1363, and in 1803 it was expanded to include the mostly Italian-speaking Trentino. In 1809, Tyrol became part of Bavaria, but it reverted to Austria in 1815. The entire South Tyrol (Trentino and German-speaking Bolzano) was given to Italy in 1919.



The shaded area of the map indicates the location of Tyrol, now divided between the Austrian province of the same name and the Italian region of Trentino-Alto Adige.

Tyrone [tir-ohn'] Tyrone, a former county of Ulster province, is in west central Northern Ireland. With an area of 3,265 km^2 (1,260 mi^2), it was the largest county in Northern Ireland. Omagh was the county town. Mountains are found in the north and southwest. Extensive moorlands occur in the center, where Lough Neagh is situated. Potatoes, barley growing, livestock raising, tourism, whiskey distilling, and the manufacture of crystal and linen are important. Tyrone became a county in the early 17th century after the English defeated the O'Neill family, which had ruled the region since the 5th century. The county was abolished as an administrative unit in 1973.

Tyrone, Hugh O'Neill, 2d Earl of Hugh O'Neill, 2d earl of Tyrone, b. *c.*1540, d. July 20, 1616, was an Ulster chieftain who led the last stand of the old Gaelic social order against English rule from 1595 to 1603. Originating in the north, his provincial rebellion spread throughout the country following initial victories and became a struggle to separate Catholic Ireland from England. Four years after his defeat and submission in 1603, O'Neill and other Irish tribal chiefs, restive in the role of mere English-style landlords, sailed to the Continent. The crown used this so-called Flight of the Earls as an excuse to confiscate their vast lands for Protestant settlement.

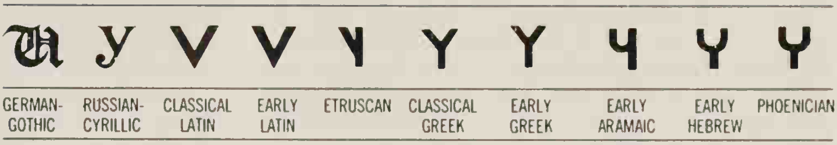
Tyrrhenian Sea [tir-een'-ee-uhn] The Tyrrhenian Sea, part of the Mediterranean Sea, lies between the Italian mainland and the islands of Sicily, Sardinia, and Corsica. It adjoins the Ionian Sea on the south and the Ligurian Sea on the north. Naples, Salerno, and Palermo are the major ports.

Tyuratam Cosmodrome see SPACE PROGRAMS, NATIONAL

Tzara, Tristan [tsah'-rah] A Romanian by birth, poet and playwright Tristan Tzara, b. Apr. 4, 1896, d. Dec. 25, 1963, is known principally as the founder of the Dada movement, which, together with Richard Hülsenbeck and Hugo Ball, he organized in Zurich in 1916. Tzara moved to Paris in 1919. After the mid-1930s, when Tzara joined the French Communist party, the tone of his writing changed noticeably. His works include the plays *La première aventure céleste de M. Antipyrine* (The First Celestial Adventure of Mr. Aspirin, 1916), *La coeur à gaz (The Gas Heart, 1923)*, and the epic poem *The Approximate Man* (1931; Eng. trans., 1973).

Tz'u-hsi, Dowager Empress of China see Cixi, Dowager Empress of China

Uu



U *U/u* is the twenty-first letter of the English alphabet. The letter is actually a variant of the next letter in the alphabet, *V/v*. The Latin alphabet used *V/v* for both consonantal *w* and vocalic *u*, but in late Latin the sound of *w* became *v*. Although the rounded form of *V/v*—*U/u*—was used in late-Latin inscriptions, the sounds *u*, *v*, and *w* were generally indistinguishable in writing. The two forms of the letter continued in use, but the differentiation of vocalic *u* from consonantal *v* by use of the letters *U/u* and *V/v* was not fully established in English writing until the 17th century.

Like all English vowels, *U/u* has a wide variety of sounds depending on the accent and the sounds surrounding it. Short *u* is usually pronounced as in *sun* or *hum*, and long *u* is normally the sound found in *rule*. In some instances there is a *y* sound before *u*, as in *use* or *mule*.

U-boat see SUBMARINE

U Thant see THANT, U

U-2 With the advent in the 1950s of the advanced U.S. single-seat reconnaissance aircraft, the Lockheed U-2, the technique of aerial reconnaissance underwent a significant and dramatic transformation. Conceived in 1954, the U-2 was designed, constructed, and operated under conditions of the utmost secrecy; its intended role was concealed by allocation of the official designation U-2 to indicate a utility airplane.

The U-2, a high-altitude reconnaissance aircraft introduced by Lockheed in 1955, took the aerial photographs revealing Soviet missile bases in Cuba in 1962.

Virtually a powered glider, the U-2 was able to attain and cruise at great heights by virtue of its unusually wide wingspan, 24.4 m (80 ft), almost twice the length of its body. The prototype U-2 was first flown in 1955. The U-2A entered service with the United States Air Force (USAF) and the National Aeronautics and Space Administration (NASA) in 1956.

Substantially increased performance was provided in the U-2B, introduced in 1959. It had a range of about 6,400 km (4,000 mi), and could fly to an altitude of 27,400 m (90,000 ft). The plane carried a comprehensive array of cameras as well as sensitive electronic equipment designed to record and monitor radio and radar transmissions.

On May 1, 1960, a U-2B flown by American Francis Gary Powers was shot down near Sverdlovsk in the USSR by a Soviet surface-to-air missile. This incident occurred only days before U.S. president Dwight D. Eisenhower and Soviet leader Nikita Khrushchev met at a summit conference in Paris. The United States at first denied that it had any planes spying on the USSR. After the Russians produced the captured pilot and parts of the plane, however, the United States admitted to the spying. Powers was released on Feb. 10, 1962, in a prisoner exchange.

Although direct overflights of the USSR ended with the Powers incident, the U-2 continued to be used elsewhere in the world. In October 1962, U-2 surveillance found evidence of Soviet missiles in Cuba, which led to the CUBAN MISSILE CRISIS. The U-2's performance also made it an excellent high-altitude research aircraft. Many of the reconnaissance duties formerly carried out by U-2s are currently handled by satellites.

Ubangi River [oo-bahng'-gee] The Ubangi River, a 2,255-km-long (1,400-mi) tributary of the CONGO RIVER in central Africa, drains an area of about 771,800 km^2 (298,000 mi^2). Rising as the Uele River just north of Lake Albert, it flows west across northern Zaire and joins the Bomu river at Yakoma, forming the Ubangi proper. It continues west, marking the Zaire–Central African Republic boundary, and then turns south, following the Congo-Zaire boundary. The upper reaches of the river were explored by Georg Schweinfurth in 1870; the link with the Congo was established by Wilhelm Junker in 1882–83.

Uccello, Paolo [oot-chel'-loh] Paolo Uccello, b. Paolo di Dono *c.*1397, d. Dec. 10, 1475, was one of the most ingenious practitioners of the art of perspective in Italian Renaissance painting. Throughout his career he was preoccupied with the effects of foreshortening and the mechanics of rendering architectural space. He accentuated these characteristics to such a degree, however, that his paintings—as opposed, for example, to those of his contemporary Masaccio—never appear to be extensions of reality.

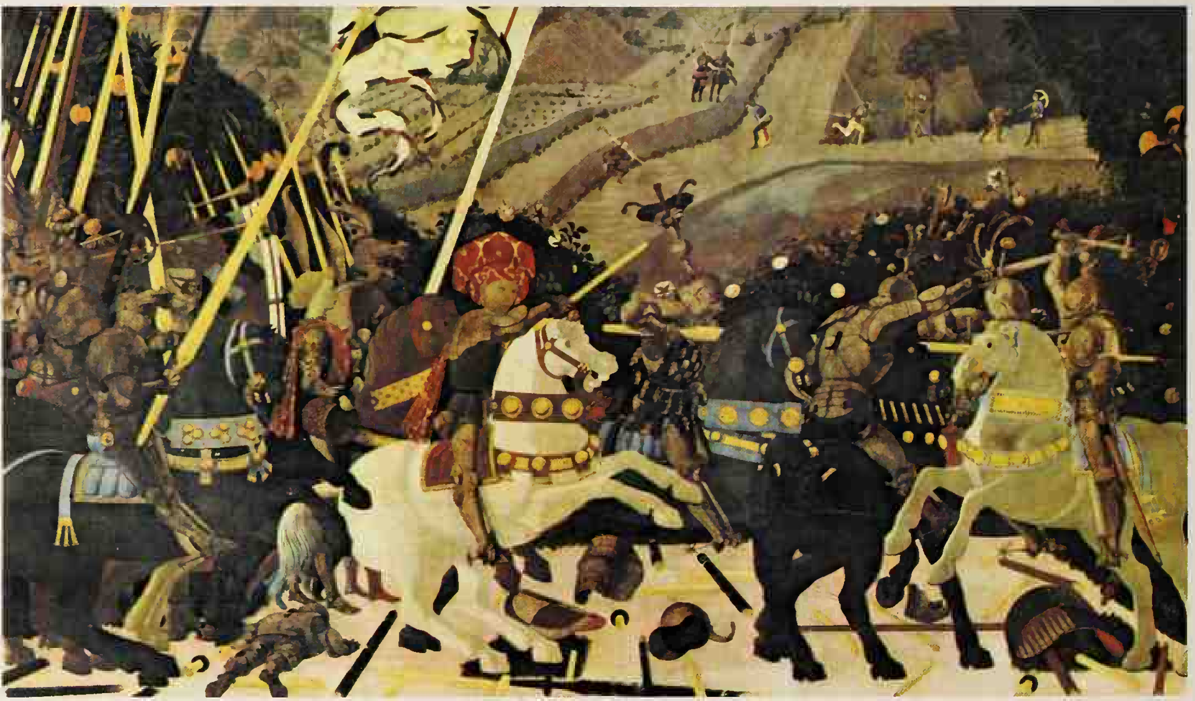
Commissioned to paint an equestrian monument of the English mercenary soldier Sir John Hawkwood, Uccello created an extraordinary fresco (1436; Florence Cathedral) depicting a monumental stone statue; the pedestal is seen from below, but the horse and rider are seen from the side. His frescoes of the Flood in the Green Cloister of Santa Maria Novella (late 1440s) manipulate the effects of perspective to the extreme.

Among Uccello's most famous paintings are three battle scenes (1455–60) now in the Uffizi in Florence, the Louvre in Paris, and the National Gallery in London. In these, brightly and irrationally colored equestrian figures battle before a tapestrylike backdrop; fallen horses, riders, and broken lances are carefully arranged along horizontal and diagonal lines that establish a gridlike perspective system. His last major commission was the predella for the altar of the Confraternity of the Holy Sacrament at Urbino (1465–69; Palazzo Ducale, Urbino). Uccello also executed many careful drawings of objects rendered in perspective.

Udall (family) [yoo'-dawl] The U.S. congressman **Morris King Udall**, b. Saint Johns, Ariz., June 15, 1922, was an unsuccessful candidate for the Democratic presidential nomination in 1976. He received his LL.B. from the University of Arizona in 1949 and practiced law until 1961, when he was elected to the U.S. House of Representatives. He served until 1991, when he resigned his seat due to ill health. His brother **Stewart Lee Udall**, b. Saint Johns, Ariz., Jan. 31, 1920, was U.S. secretary of the interior from 1961 to 1969. He also received his law degree from the University of Arizona (1948), practiced law, and represented Arizona (1955–61) as a Democrat in the U.S. House of Representatives.

Udall, Nicholas [yoo'-duhl] Nicholas Udall, b. *c.*1505, d. Dec. 23, 1556, wrote the earliest extant English comedy, *Ralph Roister Doister*, first produced at Windsor Castle in 1552. The play borrows from Plautus and Terence, but the incidents and dialogue are original, and Udall added songs and elements of farce.

In The Rout of San Romano, *the Florentine artist Paolo Uccello reconstructed a battle of 1432 in a brilliant display of perspective by placing the richly adorned figures on a grid of lances, swords, and banners. (1455–60; National Gallery, London.)*



Udine [oo'-dee-nay] Udine is the capital of Udine province in the Friuli-Venezia Giulia administrative region of northeastern Italy. Located about 65 km (40 mi) northwest of Trieste, Udine has a population of 100,211 (1987 est.). The city's industries manufacture textiles, machinery, and food products. Its arcaded central square is considered one of the loveliest in Italy. An imposing 16th-century Venetian castle overlooks the city.

Udine was laid out on a mound allegedly built by Attila the Hun in 452. It came under Venetian control in 1420 and passed to Austria in 1797. In 1866, Udine became part of Italy; from 1915 to 1917 it was the headquarters of the Italian army.

Ueberroth, Peter [yoo'-bur-awth] Peter Victor Ueberroth, b. Evanston, Ill., Sept. 2, 1937, achieved fame as president of the Los Angeles Olympic Organizing Committee (LAOOC) in 1984. He masterminded a financial plan that allowed the Games to turn a profit while costing Los Angeles taxpayers nothing. After the Olympics, Ueberroth was commissioner of baseball (1984–89).

Uelsmann, Jerry N. [ools'-muhn] The American photographer Jerry Norman Uelsmann, b. Detroit, June 11, 1934, employs innovative darkroom techniques to create photomontages that juxtapose disparate elements, some in combinations of negative and positive images. His work, which he calls postvisualization, has influenced many contemporary photographers. Widely exhibited, Uelsmann has taught at the University of Florida since 1960.

Ufa [oo-fah'] Ufa, the capital of the Bashkir Autonomous Republic within the Russian republic of the USSR, has a population of 1,083,000 (1989). Ufa is situated on the Belaya River, a tributary of the Kama, in the western Urals. The city dates from the 16th century, when it was founded by the Russians as a fortified eastern outpost. In the Soviet period it became a major petroleum-refining and petrochemical center.

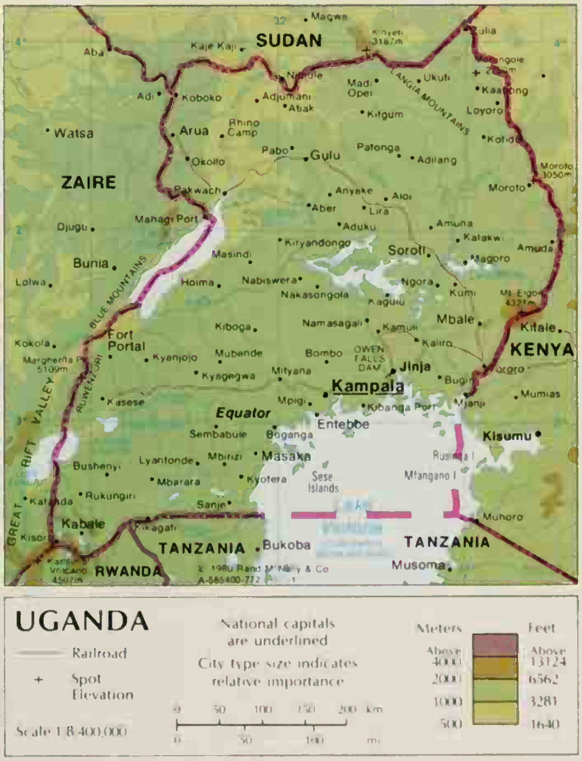
Uffizi [oof-eet'-see] The Uffizi Palace in Florence, Italy, consists of two long, connected parallel buildings by the Arno River near the Palazzo Vecchio. Commissioned (1560) as a civic structure by Cosimo I de'Medici, it was designed and in part built by Giorgio Vasari. Today the Uffizi serves as a museum that houses one of the world's major art collections.

The first rooms beyond the entrance hold three large Madonnas by Cimabue, Duccio, and Giotto and important Sienese paintings by Simone Martini and Pietro Lorenzetti. The next chamber is occupied by the works of 14th- and early-15th-century Florentine painters; additional galleries display works by other Italian masters, including Sandro Botticelli, Piero della Francesca, Leonardo da Vinci, Andrea del Verrocchio, Michelangelo, and Raphael. The Uffizi collection also includes works by important painters of the German and Flemish schools. The later 16th century in Italy is represented by Bronzino, Rosso Fiorentino, Parmigianino, Titian, and Paolo Veronese. Works from the 17th and 18th centuries include paintings by Caravaggio, Rembrandt, Claude Lorrain, and Jean Baptiste Chardin.

An extensive collection of antique sculpture is displayed along the corridors, where it is exhibited with a superb collection of Belgian and Florentine tapestries. The Uffizi's *Gabinetto dei Disegni e Stampe* holds more than 100,000 prints and drawings.

UFO see unidentified flying object

Uganda [yoo-gahn'-dah] Uganda, a small landlocked state located on the equator in East Africa, is bordered by Sudan to the north, Zaire to the west, Rwanda and Tanzania to the south, and Kenya to the east. From the time Uganda gained independence from Britain in 1962 until the National Resistance Movement (NRM) took control of the government in January 1986, each postindependence government in turn left the country in worse shape than it had found it. About 300,000 Ugandans may have been slaughtered during the rule (1971–79) of Idi Amin Dada, and mass killings resumed in the early 1980s under Milton Obote. Two wars against the central government—in



AT A GLANCE

REPUBLIC OF UGANDA

Land: Area: 236,036 km^2 (91,134 mi^2). Capital and largest city: Kampala (1980 pop., 458,503). Cocapital: Entebbe (1980 pop., 21,289).

People: Population (1990 est.): 17,960,262. Density: 76 persons per km^2 (197 per mi^2). Distribution (1987): 43% urban, 57% rural. Official language: English. Major religions: Roman Catholicism, Protestantism, Islam.

Government: Type: republic. Legislature: National Resistance Council. Political subdivisions: 33 districts.

Economy: GNP (1989): $4.25 billion; $250 per capita. Labor distribution (1985): agriculture—84%; other—16%. Foreign trade (1988): imports—$626 million; exports—$272 million. Currency: 1 Uganda shilling = 100 cents.

Education and Health: Literacy (1985): 57% of adult population. Universities (1988): 2. Hospital beds (1989): 20,136. Physicians (1984): 700. Life expectancy (1990): women—50; men—48. Infant mortality (1990): 107 per 1,000 live births.

1979 and 1981–86—further damaged the economic and social order.

Land and Resources

Uganda occupies part of a high plateau that averages 915 m (3,000 ft) in the less hilly and lower north and rises to 1,340 m (4,400 ft) near Kampala. On the southwestern border near the equator are the volcanic Virunga Mountains and the permanently snowcapped peaks of the Ruwenzori Range, including Mount Stanley (5,110 m/16,763 ft), Uganda's highest point. These mountains form part of the western branch of the East African Rift System. On the eastern border are several extinct volcanoes, including Mount Elgon. Lakes cover almost one-fifth of Uganda's area. Rivers in the south drain into Lake Victoria (see Victoria, Lake), from which the Victoria Nile flows into Lake Albert (Lake Mobutu; see Albert, Lake).

Most of Uganda has relatively reliable rainfall in two distinct wet seasons (March–May and October–November). The semiarid northeast receives 625 to 1,000 mm (25 to 39 in) of rainfall between April and August, while annual rainfall near Lake Victoria averages 1,500 mm (59 in). Temperatures reach 35° C (95° F) on the Rift floor and along the Sudanese border. In the southwestern highlands they drop to 5° C (40° F).

Copper and small amounts of gold, tungsten, tin, lead, and wolfram have been extracted, primarily in the southwest. Salt deposits near Kasese have long been mined on a small scale.

Uganda has four national parks, the newest of which was established in 1984. Tourism, formerly a leading foreign-exchange earner, has virtually disappeared since 1972, and some once-numerous wildlife species have almost disappeared.

People

While ethnic identification seldom matches cultural practices or adequately explains political action, it is regarded as important by most Ugandans. Some groups, such as the Nyoro east of Lake Albert and the Ganda north and west of Lake Victoria, have long histories. Others, such as the Gisu of Mount Elgon and the widely scattered Nubians, were created for political reasons during the colonial period. Additional groups include the Acholi and Langi of north central Uganda and the Karamojong of the northeast.

English is the official language, but Swahili is widely spoken, and Luganda is a common language in the south. Christians probably account for more than 70% of the population. Islam claims perhaps 5% of the population.

Rapid population growth has led to serious pressures on arable land, particularly in the southwest. Kampala is the capital (with Entebbe) and only large urban center. Health care, which deteriorated dramatically after independence, has been further stressed by a high incidence of AIDS. Schools, including once-famous Makerere University (1922), lack books and supplies. An Islamic university opened in 1988.

Economic Activity

During the colonial period an economy based on supplying raw materials for British industries and markets for European manufactured goods supplanted indigenous trade and technologies. The new colonial economy developed unevenly, so production and opportunities for wealth were unequally distributed—an important reason for later political difficulties.

Fundamental change occurred in 1972 when Idi Amin Dada expelled the Indians, who had controlled much of Uganda's credit and trade. Government failure to pay realistic prices for cotton, coffee, and other crops eventually caused severe declines in official sales of all crops, and the looting that accompanied both the 1979 and 1981–86 wars crippled production. Since 1979, Uganda has depended almost entirely on coffee for foreign-exchange earnings.

Severe inflation and low real wages, particularly for officials, led to widespread corruption, a black market, and banditry. Since 1986 the government has tried to end corruption, and foreign aid has increased, although severe economic problems remain. Uganda exports its goods primarily through the Kenyan port of Mombasa. The country's once-excellent road system has deteriorated badly since 1971.

History and Government

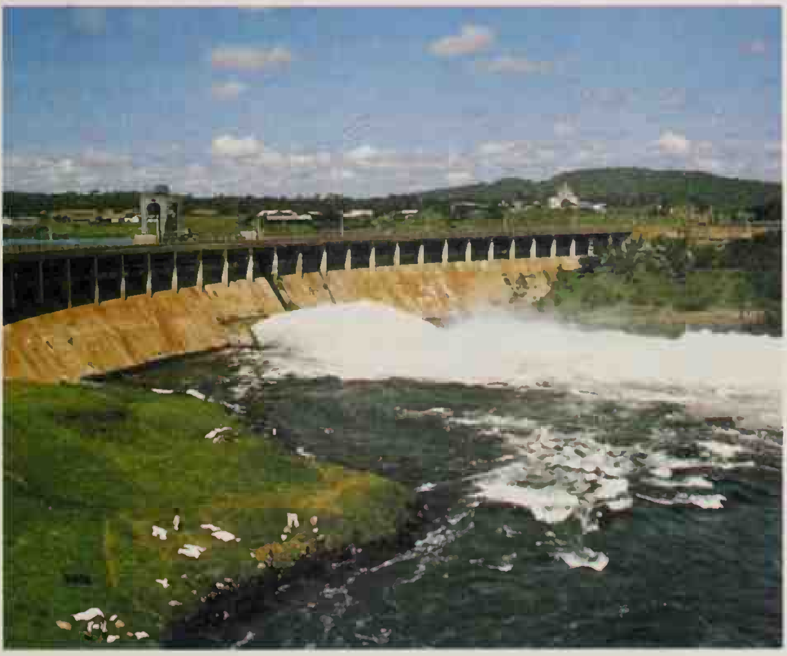
The indigenous inhabitants of what is now Uganda ranged from the ancient centralized and rival kingdoms of Buganda and Bunyoro to the decentralized Acholi and Amba. Extensive migration and trade relations previously existing among peoples throughout Uganda have been obscured by identifications reflecting the moment when British rule tended to freeze groups into their present places.

British explorer John Hanning SPEKE reached Buganda in 1862 during his successful search for the source of the Nile. Missionaries followed, and shortly after there were rivalries at the court of the Ganda kabaka (king), which led to religious persecution and then to religious wars. By siding with one faction, Capt. Frederick Lugard (later 1st Baron LUGARD) established a military presence that committed a reluctant British government to make Uganda a protectorate (1894). In 1900, Buganda's leading chiefs signed an agreement accepting British protection in return for freehold rights in land for themselves. This provided Britain with a base from which to consolidate colonial rule over the rest of Uganda.

Uganda received formal independence on Oct. 9, 1962, under an intricate federal constitution. Milton Obote, a Langi, became prime minister in an uneasy coalition with Kabaka Yekka, the Ganda party, following two sharply contested national elections. The coalition soon broke down, and a battle between the national and Buganda governments led to the exile of the kabaka, the elimination of federalism, and a direct role for the army in national politics. Obote was overthrown on Jan. 25, 1971, in a military coup led by Idi Amin Dada.

Amin, who assumed dictatorial powers, was not dislodged from power until he invaded northern Tanzania in 1978. Tanzanian troops and Ugandan soldiers in exile then liberated Kampala in April 1979 and ousted Amin's forces from the country in June.

After an unstable 18-month interim, Obote emerged



Owen Falls Dam spans the Victoria Nile as it flows from its outlet at Lake Victoria near the town of Jinja, Uganda. This dam is an important source of hydroelectric power. After its completion in 1954, new industries developed in the vicinity of Jinja.

the victor in December 1980 elections widely considered fraudulent. Yoweri Museveni, defense minister during part of the interim period, soon fled into the bush northwest of Kampala to launch a guerrilla movement (later called the National Resistance Movement, or NRM) to oppose Obote. Hundreds of thousands of Ganda were uprooted from their homes, tortured, and killed as undisciplined government soldiers made a brutal but vain effort to end the insurgency. The NRM created a disciplined army, established popular councils, and carried out political education in the areas it controlled.

On July 27, 1985, Obote was again overthrown in a military coup by a faction within his army, which then named Lt. Gen. Tito Okello head of state. The new government made overtures to the NRM, but when it invited former Amin soldiers to join it, the NRM continued to fight. Peace negotiations between the Kampala government and the NRM failed, and the NRM marched on Kampala, ousting Okello's government on Jan. 26, 1986, and taking full control of the country two months later.

During its first year in power the NRM concentrated on restoring order, rehabilitating the economy, and laying the groundwork for a new social order. Day-to-day policy-making was overseen by a broad-based cabinet headed by President Museveni. The supreme political body, the National Resistance Council, formally constituted itself as a legislature in 1988. Legislative elections were held in 1989; the government's term in office was extended to 1995 later that year.

Ugarit [oo-guh-reet'] The ancient city of Ugarit and its port have been identified with the mound of the present-day village of Ras Shamra and the small harbor of Minet-el-Beida, 10 km (6 mi) north of Latakia, in northwestern Syria. The site is of immense importance for the understanding of Canaanite civilization.

Although efforts in the field have been concentrated principally on the Late Bronze Age city, the site was occupied as far back as the 7th millennium BC. Because the kingdom of Ugarit was under Egypt's political control, many of its rulers are known from the written records of Egypt, Mesopotamia, and Hittite Anatolia. From the time of Niqmadu II of Ugarit (*c.*1360–1330 BC), tablets discovered at Ras Shamra itself provide valuable evidence concerning the customs, institutions, and culture of the city. Ugarit's influence extended over a considerable area; its port was an important commercial center for trade with Egypt, Anatolia, and the Aegean world.

Excavations have revealed the vast palace of Niqmadu covering about 10,000 m^2 (107,600 ft^2) and containing 90 rooms. Several archives have been found bearing tablets written in various languages: Babylonian, Hurrian, Cypro-Minoan, Sumerian, and Hittite cuneiform and Egyptian and Hittite hieroglyphic. Of greatest interest were those written in a previously unknown language, now called Ugaritic. Composed of the Babylonian system of cuneiform (wedge-shaped) signs, this language was West Semitic and alphabetic, showing similarities to later Hebrew, unlike the syllabic Babylonian system. The Ugaritic alphabet, composed of some 30 characters, may have been the first true alphabet.

In addition to a second, smaller palace, many private houses and two temples, dedicated to Baal and to Dagon, have been excavated. The cosmopolitan nature of the city, the result of its extensive trading, is reflected in its art objects.

In the late 13th century BC, Ugarit was destroyed by the SEA PEOPLES. Occupation was not resumed, and the site lay abandoned until the 6th or 5th century BC, when a small Greek settlement was established there.

Uhuru [oo-hoo'-roo] *Uhuru* (Swahili: freedom) was the name given to the first in a series of three Explorer satellites developed for NASA to investigate X-ray and gamma-ray sources both inside and outside the Galaxy. It was launched in 1970 atop a SCOUT rocket from the Italian San Marcos platform off the coast of Kenya, on Kenya's Independence Day, December 12. It is also known as *Small Astronomy Satellite 1, SAS 1,* and *Explorer 42.*

Uhuru and its two subsequent (1972 and 1975) companions—*Explorers 48* (*SAS 2*) and *53*—were all highly successful and laid the groundwork for more advanced satellites. *Uhuru* produced data that led astronomers to argue the existence of superclusters of galaxies bound together by a hot but thin gas with a mass many times that of the galaxies themselves (see X-RAY ASTRONOMY).

Uighur [wee'-gur] The Uighur are the major ethnic group of the Chinese province of Xinjiang. Speakers of a southeast Turkic variety of the URAL-ALTAIC LANGUAGE family, they are basically of Mongoloid racial stock and tend to resemble more closely Central Asian TURKS than the Chinese Mongolian physical type. In the mid-1980s the Uighur numbered nearly 6,000,000 in Xinjiang and more than 211,000 in the USSR, chiefly in the Uzbek and Kirghiz republics.

The Uighur originated on the Mongol steppes during the 6th century AD, and by 744 they were absolute rulers of their realm (see MONGOLS). Defeated (840) by the Yenisey Kirghiz, they fled into Xinjiang. Originally NOMADS, the Uighur shifted early to settled agriculture. For 11 centuries they lived on irrigated oases of the Tarim River basin and also in cities, where they have worked as merchants, shopowners, and innkeepers. Their indigenous religion combined shamanistic and Buddhist traditions, but they converted to Sunni Islam about 900.

The name *Uighur* passed out of usage from the period of the Mongol conquests (1200s) to the 1920s, when it was revived by the Soviets and the Chinese. *Uighur* undoubtedly is related to the Chinese term *Hui,* meaning Muslims.

Ukiyo-e [oo'-kee-yoh-ay] Ukiyo-e (literally, "pictures of the floating world") was a school of art that flourished in Japan from the mid-17th to the mid-19th century. The rough equivalent of lower-class genre art in the West,

Courtesan *(18th century) epitomizes the subtle emotional rendering and elegance of the artwork of Suzuki Harunobu, an artist preeminent in the Japanese Ukiyo-e school. Ukiyo-e, an art form using colored wood-block prints to portray popular scenes, reached its height during the 18th century. (Musée Guimet, Paris.)*

Ukiyo-e encompassed paintings, wood-block prints, and illustrated books that reflected the delight of the Edo (modern Tokyo) middle classes in the sensuous pleasures of the commoner's world. (See JAPANESE ART AND ARCHITECTURE.)

Beginning with the monochrome prints of Hishikawa MORONOBU, the school's nominal founder, and the erotic album illustrations of his contemporary Sugimura Jihei (fl. 1680–98), Ukiyo-e artists took as their primary subjects the beautiful and licentious courtesans of Edo's demimonde. Ukiyo-e art was expanded and revitalized significantly when the Torii masters KIYONOBU I and Kiyomasu began dominating (*c.*1700) the print world of Edo with their hand-colored broadsheets depicting actors of the kabuki, or popular theater. Matinee idols of the popular stage and courtesans of the pleasure districts continued to dominate the Ukiyo-e world until the emergence of landscapists in the 19th century.

In the 1740s publishers perfected a registration process for multiple printing with colors, an innovation generally credited to the artist Okumura MASANOBU. This phase of Ukiyo-e art culminated in the spectacular polychrome prints of the six great masters of the period 1750–1850: Suzuki HARUNOBU, Torii KIYONAGA, Kitagawa UTAMARO, Toshusai SHARAKU, and the landscapists Katsushika HOKUSAI and Ando HIROSHIGE. These artists produced lively masterpieces in alliance with craftsmen who skillfully translated their designs into the wood-block medium.

Ukiyo-e prints gained wide popularity among Western collectors during the late 19th century and exerted a significant influence on several impressionist and postimpressionist artists. Ukiyo-e is the most universally known and appreciated of all the Japanese arts.

Ukrainian language see SLAVIC LANGUAGES

Ukraine [yoo-krayn'] Ukraine was one of the 15 constituent republics of the USSR, but it became independent in 1991. The country occupies the north shore of the Black Sea and the Sea of Azov and borders in the west on Romania, Hungary, Czechoslovakia, and Poland. The area is about 603,677 km^2 (233,089 mi^2), and the population is 51,100,000 (1991 est.). The republic's capital is KIEV (1991 est. pop., 2,635,000). The name *Ukraine* means "border territory," reflecting its position on the Polish frontier.

Most of Ukraine is physically part of the Russian, or East European, plain; the only uplands are the Ukrainian segment of the CARPATHIAN MOUNTAINS in the southwest, and the Crimean Mountains along the southern coast of the CRIMEA. The principal rivers are the DNEPR, the DNESTR, the Donets, and the Southern Bug.

The Ukrainian people, who represent 75% of the population, are a Slavic group, Russian Orthodox in religion, whose language is related to Russian and Polish (see SLAVIC LANGUAGES). Russians represent less than 20% of the population and live mainly in cities, whereas the ethnic Ukrainians are only 45% urban. Jews are an important urban minority. The principal cities in addition to Kiev are DNEPROPETROVSK, DONETSK, KHARKOV, LVOV, ODESSA, and ZAPOROZHYE.

Economically, Ukraine was the USSR's second most important republic, after the Russian republic. Rich in mineral resources, it had the USSR's largest coal-producing district, the DONETS BASIN, and the biggest iron-ore mining area, at KRIVOI ROG. The republic accounted for more than 40% of the Soviet steel output and also mined most of the USSR's manganese and titanium ores. Manufacturing is highly developed and diversified, producing a wide range of machinery and industrial equipment and chemicals. Ukraine is also a key agricultural region.

In 1986 a serious accident at the CHERNOBYL nuclear power plant north of Kiev spread harmful radiation across Ukraine and into neighboring countries, forcing the evacuation of 135,000 people from the immediate area.

The medieval Russian state known as Kievan Rus' was centered at Kiev and included portions of what later became Russia and Ukraine. An independent state, the Kingdom of Galicia and Volhynia, existed in western Ukraine in the 13th and 14th centuries. By the beginning of the 15th century, most of Ukraine had been absorbed by the Kingdom of Poland-Lithuania (after 1569, the Kingdom of Poland). Eastern Ukraine became independent in 1654 but quickly fell under Russian control. Western Ukraine remained Polish until the partitions of Poland (1772–95), when most of it was also annexed by Russia. After the Russian Revolutions (1917), a portion of the western area was restored to Poland; in the remainder of Ukraine the Bolsheviks defeated nationalists who wanted independence, forming the Ukrainian republic, which became part of the Soviet Union in 1922.

Millions of Ukrainians died of famine during the agricultural collectivization of the early 1930s. During World War II some Ukrainians sided with Germany against the Soviet Union, and in Polish Ukraine (seized by the USSR in 1939) nationalist guerrillas resisted Soviet rule until the early 1950s. The territory of the Ukrainian republic was enlarged by the addition of Carpathian Ukraine (RUTHENIA), taken from Hungary in 1945.

Together with the other Soviet republics, Ukraine became independent in late 1991, and under the leadership of Leonid Kravchuk, a former Communist turned nationalist, it began to carve its new identity.

ukulele [yoo-kuh-lay'-lee] The ukulele is a small, guitar-shaped instrument with four strings, a fretted fingerboard, little resonance, and more harmonic than melodic capabilities. Its music is notated in simple tablature that shows finger placement on the strings. The instrument originated in Hawaii and had a vogue in American collegiate life and amateur music in the 1920s and '30s.

The ukulele is a small guitar-like stringed instrument developed (c. 1877) in Hawaii from the Portuguese machête.

Ulan Bator [oo'-lahn bah'-tor] Ulan Bator, the capital and largest city of Mongolia, lies in the north central part of the country. The city's population is 548,400 (1989 est.). An economic and transportation center, Ulan Bator has textile, leather, lumber, cement, meat-packing, and pharmaceutical plants and is the seat of the National Choibalsan University (1942).

The site of Ulan Bator, along the caravan route between Russia and China, was settled in 1639 as a Lamaist monastery and named Da Khure. Mongolian autonomy was proclaimed there in 1911. The Soviet Red Army occupied the city in 1921, and in 1924, when Mongolia became a people's republic, it was given its present name, which means "Red Hero."

Ulanova, Galina Sergeyevna [oo-lah'-noh-vah] Galina Sergeyevna Ulanova, b. Saint Petersburg (now Leningrad), Jan. 10 (N.S.), 1910, whose name has become a symbol for Soviet ballet, joined the Leningrad Kirov Ballet in 1928; in 1944 she was transferred to Moscow's Bolshoi Ballet. Ulanova was celebrated for her interpretations of the touchstone ballets of the international repertoire, and was equally identified with such peculiarly Russian classics as *The Humpbacked Horse.* Although Ulanova did not appear outside the Soviet Union until 1951, when she was past her physical prime, her artistry was given tumultuous recognition in the West. Her dancing, characterized by the sustained flow of movement known as the cantilena style, had a profound purity and simplicity.

Ulbricht, Walter [ool'-brikt] Walter Ulbricht, b. June 30, 1893, d. Aug. 1, 1973, was dictator of East Germany. He joined the German Communist party when it was established in 1918, then studied in Moscow in the early 1920s and during 1928–33 was a member of the the Reichstag. When Adolf Hitler came to power in 1933, Ulbricht left Germany, serving as a Comintern agent and working with the Russians during World War II. In 1949, Ulbricht became deputy prime minister of the newly established German Democratic Republic and next year became secretary of the Socialist Unity (Communist) party. His harsh regime provoked an open rebellion in 1953 and a stream of refugees to West Germany, stopped only by the Berlin Wall, built in 1961. As the result of strikingly successful economic reforms introduced during the last decade of Ulbricht's rule, East Germany achieved the highest standard of living in the Communist world. Ulbricht relinquished the powerful party secretaryship in 1971 but remained chairman of the Council of State, retaining, until his death, the titular dignity of German head of state.

ulcer An ulcer is a pitting of a mucous or skin surface that results from an erosion or disintegration of the tissues. Ulcers of the gastrointestinal tract, called peptic ulcers, are relatively common and are thought to occur in 1 to 20 percent of the population in developed countries.

Peptic Ulcers. Peptic ulcers occur most commonly in the duodenum near the junction with the stomach, and in the stomach wall. They generally occur singly as round or oval lesions. The erosions are typically shallow but can penetrate the entire wall, leading to hemorrhage and possibly death. Pain, the predominant symptom, occurs one to three hours after a meal and is usually relieved with alkalis. The cause of such ulcers is not established, although Australian researchers in 1984 suggestively linked the presence of a newly observed form of *Campylobacter* bacteria with their development. The occurrence of some ulcers has also been linked with the use of the antiarthritis drugs called NSAIDS.

At any rate, when gastric juices (consisting of hydrochloric acid, mucus, and a digestive enzyme called pepsin) act upon the walls of the digestive tract, a peptic ulcer results. The fact that ulcers of the duodenum are frequently associated with excess secretion of gastric acid and that ulcers of the stomach are not suggests that the two lesions may be separate disease entities. Entry of acid-peptic contents from the stomach into the lower esophagus can also cause ulcers in that area. Peptic ulcers tend to become chronic.

Chronic peptic ulcers seem to be more related to psychological factors than are the so-called "stress ulcers" discussed below, but no identifiable psychological injuries have been reported. A chronic peptic ulcer develops when there is imbalance between normal "aggressive" factors, the acid-peptic secretions, and normal "resistance" factors such as mucous secretions and rapid cellular replacement.

Stress Ulcers. Stress ulcers usually occur in the stomach and are seen as multiple, shallow, bleeding erosions. They tend to heal rapidly because of their shallowness, but they can perforate and cause severe bleeding. They generally cause less pain than the chronic peptic ulcer. The term *stress* has led to misconceptions about the role of psychological factors in their development, because they occur most often in patients who have experienced physical injury such as severe trauma, burns, or major surgery, and are more common in elderly or debilitated patients. Stress ulcers resulting from central-nervous-system disease are called Cushing's ulcers.

Treatment. Ulcers, whether chronic or stress, can usually be treated by medical therapy alone. The drugs most commonly used are alkaline buffering agents and a special class of antihistamine called cimetidine, which blocks the histamine-2 receptors in the stomach that regulate gastric secretion. Newer drugs and drugs under development include sucrasulfate, prostaglandin compounds, and anticholinergic agents.

When drug therapy alone fails, surgery is attempted. This may include removal of the distal part of the stomach, which produces the gastric stimulant hormone called gastrin, combined with severing of the vagus nerves to remove stimulation from the central nervous system. Surgery can sometimes be averted by using endoscopes to bring laser heat or electric currents to the ulcer site to stop bleeding.

Skin Ulcers. Ulcerations of the skin may occur as a result of the actions of bacterial toxins, as in anthrax ulcerations and chancres of syphilis. In diseases such as tuberculosis the toxins may enter the bloodstream and ulcerate the linings of the bladder, lungs, or other organs. Decubitus ulcers, or bedsores, result from the pressures exerted by prolonged bed rest. Ulcers also may occur on legs and feet because of the poor or blocked circulation that can result from, for example, arteriosclerosis, emboli, and infarctions. Diabetes tends to increase their incidence. Therapy may involve topical treatment—using drug-containing ointments, pastes, or powders—or systemic drug administration.

Ullmann, Liv [ool'-mahn] A Norwegian dramatic actress, Liv Ullmann, b. Tokyo, Dec. 16, 1938, is best known for the films she has made with Ingmar BERGMAN. Most striking in *Persona* (1966), she has also given fine performances in *Shame* (1968), *Cries and Whispers* (1972), *Scenes from a Marriage* (1974), *Face to Face* (1976), *Autumn Sonata* (1978), and in Jan Troell's *The Emigrants* (1972). She appeared in a few New York theater productions in the 1970s and '80s.

Ulster [uhl'-stur] Ulster, the northernmost of the four ancient Irish kingdoms, encompasses NORTHERN IRELAND and three counties of Ireland. Ulster was dominated by the earls of Tyrone (O'Neill clan) and the earls of Tyrconnell (O'Donnell clan) from the 5th century until the 12th-century Anglo-Norman invasion. Ulster's clans (see TYRONE, HUGH O'NEILL, 2D EARL OF) unsuccessfully rebelled against England from 1594 to 1601. King James I of England colonized the area with Scottish Presbyterians. Descendants of these Protestants led the opposition to Irish home rule, and in 1920 they forced the partition of Ireland, with most of Ulster remaining under British rule.

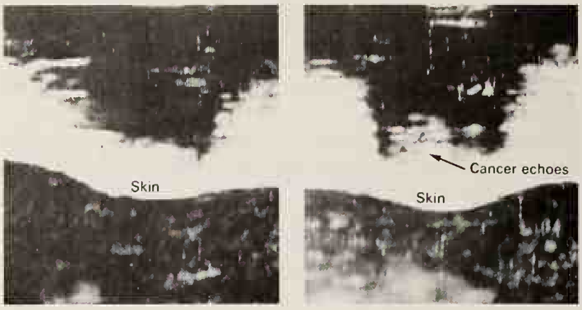
ultramontanism [uhl-truh-mahn'-tuh-nizm] Ultramontanism (from Latin, meaning "beyond the mountains"; specifically, beyond the Alps, in Rome) refers to the position of those Roman Catholics who historically have emphasized the importance of centralized papal authority over the authority of kings and regional ecclesiastical hierarchies. It was often used in opposition to such nationalist positions as GALLICANISM (France), Josephinism (Austria), and Febronianism (Germany), which favored strong national churches, and to CONCILIARISM, which subordinated the pope's authority to that of a council of bishops. From the 17th century, ultramontanism became closely associated with the attitude of the Society of Jesus as elucidated by theologians such as Francisco SUÁREZ. The ultramontanists attained their greatest triumph in the late 19th century with the formal proclamation (1870) of papal primacy and INFALLIBILITY.

ultrasonics *Ultrasonics* is the term used to describe the study of all soundlike waves whose frequency is above the range of normal human hearing. Audible sound frequencies (see SOUND AND ACOUSTICS) extend from about 30 to 20,000 hertz (1 Hz = 1 cycle per second). The actual waves and the vibrations producing them are called ultrasound. As late as 1900 ultrasound was still a novelty, and by 1930 it was a small area of physics research. In the 1960s and '70s, however, it became a research tool in physics, an instrument for flaw detection in engineering, a rival to the X ray in medicine, and a reliable method of underwater sound-signaling. The range of frequencies available has been extended to millions and even billions of hertz (megahertz and gigahertz).

Generation. The principal modern sources of ultrasound are specially cut crystals of materials such as quartz or ceramics such as barium titanate and lead zirconate. The application of an alternating electrical voltage across the opposite faces of a plate made of such a material produces an alternating expansion and contraction of the plate at the impressed frequency. This phenomenon in crystals is known as PIEZOELECTRICITY.

Wave Properties. Ultrasonic waves travel through matter with virtually the same speed as sound waves—hundreds of meters per second in air, thousands of meters per second in solids, and 1,500 m/sec (5,000 ft/sec) in water. Most of the properties of sound waves (reflection, refraction, and so forth) are also characteristic of ultrasound. The attenuation of sound waves increases with the frequency, however, so that ultrasonic waves are damped far more rapidly than those of ordinary sound. For example, an ultrasonic wave of 1 MHz frequency passing through water will lose half of its intensity over a distance of 20 m (66 ft) through absorption of the energy by the water.

Physical Applications. Ultrasound is widely used in



(Above) *The ultrasonic pulse-echo technique of medical diagnosis was first used by doctors in 1950 to detect tumors. A woman's breast was scanned with ultrasound, and the reflections from different regions were displayed on a cathode-ray tube. The scan of a normal breast* (shown at left) *was found to differ from that of a tumorous breast* (right). (Below) *Ultrasound scans have become a common diagnostic tool. Holding the scanner above the kidneys of a patient, the technician observes the resulting image on the screen at the side of the bed.*

the detection of obstacles in materials that do not transmit light. For example, a low-frequency ultrasonic beam can penetrate many kilometers of the ocean and be reflected back from an obstacle there. This is the principle of SONAR, which is used to identify submarines, map the ocean bottom, and measure the thickness of ice packs. Industrially, this same principle is used to detect flaws in solids. When a short pulse of ultrasound is sent into a metal, for example, it is reflected back from any cracks or minute defects such as blowholes. The concept is further extended by the combined use of light and sound in what is called acoustic HOLOGRAPHY. In this method, an ultrasound beam traveling through water agitates the water's surface. A light beam reflected from this surface is modulated by the pattern of agitation, and the modulated beam can then be used to reconstruct the original sound beam. If the sound beam is first directed through an object, it is thus possible to reconstruct images of the object's interior.

The intense small-scale vibrations of ultrasound are also used industrially to shake dirt or other deposits off metals. The ultrasonic transducer, by removing oxides from metal surfaces, aids in the processes of soldering and welding. Plastic powders can be molded into small cylinders by similar techniques. Ultrasound is further used in the atomization of liquids and even metals, and in the precipitation of smoke particles before they enter the environment.

Medical Applications. Ultrasonic transducers also serve in medicine in numerous ways. The vibrations of a transducer can be conveyed to a cutting edge in ultrasonic drills and saws—for use in surgery and dentistry, for example. Pulses of ultrasound can be sent into the body without the need for surgery, as well, to shatter kidney stones and gallstones (see LITHOTRIPSY).

More generally, ultrasonic transducers have come to be widely used in medical imaging (see RADIOLOGY) for the diagnosis of disease states and the evaluation of internal organs and structures. Because different portions of the body reflect and scatter sound waves at different rates, the returning echo can be formed into a picture of these structures. A handheld transducer is moved across the part of the body to be scanned, coupled to the skin with a gel or liquid to prevent air from interfering with the transmission of sound waves. The painless procedure takes anywhere from a few minutes to an hour.

Ultrasound provides information about tumors and cysts that cannot be obtained by conventional X-ray studies. Echocardiography, the study of heart motions by ultrasonic means, is another medical application. Ultrasonics plays a significant role in observing pregnancy problems, as well, and is often the first screening examination for many medical conditions that affect children.

The dissipation of sound energy in a medium results in local heating and motion of any fluid present. These phenomena are useful in ultrasonic therapy or massage. Highly concentrated beams of ultrasound can also be used to destroy cells and have had some medical applications, as in treatment of secondary glaucoma.

ultraviolet astronomy Ultraviolet astronomy relates to celestial observations made in the ultraviolet region of the electromagnetic spectrum, ranging from wavelengths of about 4000 Å down to about 100 Å. The OZONE LAYER in the Earth's upper atmosphere, as well as atmospheric oxygen and nitrogen, effectively keep all ultraviolet radiation with wavelengths shorter than 2900 Å from reaching the Earth's surface. Thus Earth-bound astronomers were for a long time kept from observing the radiations of celestial objects in this range of wavelengths. The development of the field of ultraviolet astronomy began only with the orbiting of space observatories in the 1960s.

Observing celestial objects in ultraviolet light allows astronomers to obtain valuable information about the nature of such peculiar objects as quasars, Seyfert galaxies, and unusual radio galaxies. The presence and amounts of most elements in interstellar space can be determined only by ultraviolet studies, because the strongest spectral lines of the lighter, most abundant interstellar elements are strongest in the ultraviolet re-

This photograph of a solar prominence, or an eruption of gas from the Sun's visible surface, was taken in ultraviolet (UV) light. The image has been color coded to reveal differences in gas density.

gion. Most of the light from hot stars is also ultraviolet, and the properties of hot stars, white dwarfs, planetary nebulas, and even the atmospheres of stars and planets can be obtained more directly from ultraviolet than from visible-light observations.

The Sun's chromosphere and corona have been intensively studied in ultraviolet light since Mar. 7, 1962, when the first of a series of eight Orbiting Solar Observatories (see OSO) was launched. The *Copernicus* satellite, the second of two Orbiting Astronomical Observatories (see OAO) to operate successfully in orbit, was launched on Aug. 21, 1972, and functioned until early 1981.

A more advanced satellite called the *International Ultraviolet Explorer* (IUE) was placed in geosynchronous orbit on Jan. 26, 1978. It has recorded spectra from quasars, peculiar galaxies, collapsed stars, planetary nebulas, interstellar gas clouds, and thousands of individual stars. A still more advanced satellite, the *Extreme Ultraviolet Explorer* (EUE), is planned for the early 1990s. Equipped with four mirrors, it will observe the universe in the extreme ultraviolet region of the spectrum for the first time.

ultraviolet light Electromagnetic radiation having wavelengths shorter than visible light but longer than X rays is called ultraviolet light, or ultraviolet radiation. This light is invisible to human eyes and is also known as black light. The ultraviolet region of the spectrum was discovered in 1801 by John Ritter in the course of photochemical experiments.

Ultraviolet light is generally divided into the near (4000 to 3000 Å), the far (3000 to 2000 Å), and the vacuum (2000 to 40 Å) ultraviolet regions. The last wavelengths, which are particularly harmful to life, are strongly absorbed by the Earth's atmosphere and particularly by the OZONE LAYER.

Ultraviolet light is created by the same processes that generate visible light—transitions in atoms in which an electron in a high-energy state returns to a less energetic state. Fluorescent and mercury-vapor lamps produce large amounts of ultraviolet light, which is filtered out when the lamps are intended for optical use.

Biological effects of ultraviolet light include sunburn and tanning. Excessive exposure has been linked to the development of skin cancers and of cataracts in the eye. Far ultraviolet light, which has the ability to destroy certain kinds of bacteria, is used for sterilizing foodstuffs and medical equipment.

Ulysses (mythology) see ODYSSEUS

Ulysses (novel) [yoo-lis'-eez] The most influential novel of the 20th century, James JOYCE's *Ulysses* (1922) is a modern epic whose structure loosely parallels that of Homer's *Odyssey*. Set in Dublin, the novel deals with one day (June 16, 1904) in the lives of Leopold Bloom, a wandering Jew whose sense of estrangement from society makes him a universal symbol of humanity, Stephen Dedalus, and Leopold's sensuous wife, Molly, whose final affirmation of life is given in the lengthy interior monologue that concludes the book. *Ulysses* is noted for its erudite allusions to theology, mythology, history, and language; its stylistic virtuosity; its masterful use of the interior monologue and other innovative STREAM OF CONSCIOUSNESS techniques; its encyclopedic breadth of detail; and, above all, its richly comic portrayal of life. Banned from the United States as obscene until 1933, *Ulysses* is today considered one of the highest achievements of modern literature. A controversial new edition of *Ulysses*—the first since 1961 and the result of 7 years of computer-assisted work—was published on Bloomsday 1984, purportedly correcting about 5,000 printer's errors.

Umar I [oo-mahr'] The second Muslim caliph (r. 634–44), Umar I, b. *c.*581, d. Nov. 3, 644, did much to extend and consolidate the empire of Islam. A father-in-law of the prophet Muhammad, he was named by Abu Bakr, the first caliph, to be his successor. Umar spread Islam by conquest into the Byzantine lands of Palestine, Syria, and Egypt, and into the Sassanian Persian Empire, establishing the principles of Islamic law in the conquered areas. He was killed by a Persian slave.

Umar, al-Hajj Al-Hajj Umar, b. *c.*1794, d. Feb. 12, 1864, was a major intellectual and political figure in the 19th-century Islamic revolutions in West Africa. A member of the Tokolor tribe of Senegal, he was appointed caliph for West Africa by the reformist Tijaniyya brotherhood in Mecca. Beginning in the 1840s, Umar and his armed followers overthrew many West African rulers and established a strong Tokolor empire centered on present-day Mali. Al-Hajj Umar was killed during an uprising by the Muslim FULANI of Maçina and other peoples. But his son and successor, Ahmadu Tijani, maintained the Tokolor state until French conquest in 1893.

Umayyads [oo-mah'-yahdz] The Umayyads were an Islamic dynasty established by the caliph MUAWIYAH I in 661. An earlier caliph, Uthman (r. 644–56), had been a member of the powerful Umayyad clan, but he was murdered and replaced by ALI. When Muawiyah, previously governor of Syria, seized the caliphate, he made the succession hereditary. From their capital at Damascus, the Umayyad caliphs ruled a vast empire, extending from Europe to India, until 750. The line continued in Spain until 1031.

In place of the theocratic government of the early caliphs, Muawiyah created a more autocratic and secular regime. Islam was reserved as a privilege of the Arabs and was not forced on the conquered peoples, whose society was preserved and strongly influenced the government, art, and economy of the dynasty. In government, Muawiyah adopted the bureaucratic structure of the former Byzantine state.

A policy of continuous expansion, reaching its maximum extent under al-Walid I (r. 705–15), brought northwest Africa, Spain, western India, and portions of Central Asia into the Islamic empire and added greatly to Umayyad wealth. This expansion was the result of an efficient Syrian army and a powerful navy. The Umayyad period was characterized by Arabization—the spread and intermarriage of Arabs with native peoples and the adoption of Arabic as the common language within the empire. The dynasty collapsed because of internal tribal and geographical rivalries and a return to the principles of Islam as the foundation of the state. It was overthrown by the ABBASIDS, who massacred most members of the family. The Umayyad dynasty survived only in Spain, where ABD AL-RAHMAN I founded (756) the Umayyad emirate (later caliphate) of Córdoba.

Umberto for Italian kings of this name, see HUMBERT

umbilical cord [uhm-bil'-i-kul] The umbilical cord, which occurs in placental mammals, arises from the abdomen of a developing fetus and attaches to the placenta. It is the tissue through which the fetus obtains its food and oxygen from and expels its waste products into the mother's circulatory system. About 0.6 m (2 ft) long and 1.2 cm (0.5 in) in diameter in humans, the umbilical cord contains two arteries and a single vein. Just after birth, when it is no longer needed, the umbilical cord is cut, and the former site of attachment is known as the umbilicus, or navel.

See also: DEVELOPMENT, HUMAN; PREGNANCY AND BIRTH.

umbrella plant Umbrella plant is the common name for several species in the genera *Cyperus* and *Peltiphyllum* of the families Cyperaceae and Saxifragaceae, respectively. The name refers to the plant's flower cluster or drooping leaves extending from a single stock, which has the appearance of an umbrella. *P. peltatum* is a popular California garden plant.

Umbria [oom'-bree-ah] Umbria is a region in the Apennine mountains of central Italy, northeast of Rome, covering about 8,456 km^2 (3,265 mi^2) in area. Its population is 819,562 (1989 est.). Umbria encompasses the two provinces of Perugia and Terni. The regional capital is PERUGIA. Umbria is largely agricultural, producing grapes, sugar beets, and olives. Cattle and hogs are also raised. Chemicals, iron and steel, processed foods, and textiles are manufactured. Umbria's beautiful countryside and medieval cities, including ASSISI, Orvieto, Perugia, and Spoleto, are tourist attractions.

Umbria fell to Rome in the 3d century BC. Various warring tribes controlled the region in the early Middle Ages. Largely an area of independent fiefdoms from the 12th century, Umbria was part of the PAPAL STATES from the 16th century until 1860, when it joined newly united Italy. The region was occupied by Allied troops in June and July of 1944.

Un-American Activities, House Committee on The House Un-American Activities Committee (HUAC) was established (1938) as a special committee by the U.S. House of Representatives. Under the chairmanship of Texas Democratic representative Martin Dies, Jr., it investigated fascist, communist, and other so-called extremist or subversive political organizations. In January 1945 it became a standing committee. The Dies Committee, as it was first called, investigated the German-American Bund and the Silver Shirt Legion, both pro-Nazi organizations, and the U.S. Communist party's infiltration of the Federal Theatre Project and the Federal Writers Project. Its original intent was to halt Axis propaganda in the United States, but much of its attention was eventually centered on New Deal liberals, artists and intellectuals, and labor leaders.

After World War II and over the next 30 years, HUAC concentrated its efforts primarily on communist and left-wing organizations. In October 1947 it presented evidence that ten Hollywood writers and directors had communist affiliations. The HOLLYWOOD TEN, as they were called, refused to affirm or deny the charges made against them and were jailed for contempt. In 1948, HUAC's investigation of communists in the higher levels of the State Department led to its famous hearings on Alger HISS. In 1950 the committee, responding to the red-scare tactics of Sen. Joseph P. McCarthy, Republican of Wisconsin, sponsored a bill requiring U.S. communists to register as foreign agents, denying them passports, and excluding them from government and defense-industry

Robert Stripling (left), *chief investigator for HUAC, and Rep. Richard M. Nixon examine the microfilm of State Department documents used as evidence in the 1948 hearings involving Alger Hiss and Whittaker Chambers.*

employment. This bill became law as the McCarran Act, but the registration provision and travel ban were eventually overturned by the courts. In 1969, HUAC was renamed the Internal Security Committee and in 1975 it was abolished.

Unamuno, Miguel de [oo-nah-moo'-noh] An important Spanish philosopher whose writings defined modern existentialist issues, Miguel de Unamuno y Jugo, b. Sept. 29, 1864, d. Dec. 31, 1936, was also an innovative novelist, playwright, and poet. A Basque and self-styled provincial who lived in Madrid only long enough to obtain (1884) his doctorate, Unamuno spent the rest of his life at the University of Salamanca or in exile (1924–30). Although at first a socialist, his political ideas were peculiarly his own.

Unamuno's philosophical and literary writings are also difficult to categorize. Raised a devout Catholic, he experienced a religious crisis in 1897. Afterward he stressed the struggle to believe rather than faith itself. Although his first novel *Paz en la guerra* (Peace in War, 1897) was realistic, his later works were either experimental or confessional. His most famous novels are *Mist* (1914; Eng. trans., 1928) and *San Manuel Bueno, mártir* (1933; Eng. trans., 1957). Although also an original poet, Unamuno is best known for his essays: *Life of Don Quixote and Sancho* (1905; Eng. trans., 1927), *The Tragic Sense of Life* (1913; Eng. trans., 1921), and *The Agony of Christianity* (1924; Eng. trans., 1928).

Uncas [ung'-kuhs] The Mohegan chief Uncas, *c.*1606–*c.*1683, was the leader of the pro-English, accommodationist faction of his tribe. He married the daughter of the tribe's anti-English paramount chief, Sassacus, and led a rebellion against him. When Sassacus was deposed and the Pequot defeated (1637), the ambitious Uncas gained control of the reunited Pequot-Mohegan tribe. With English support Uncas launched a campaign of conquest against other New England tribes, which made his people the most powerful Indians in New England. In 1675 he sided with the English during King Philip's War.

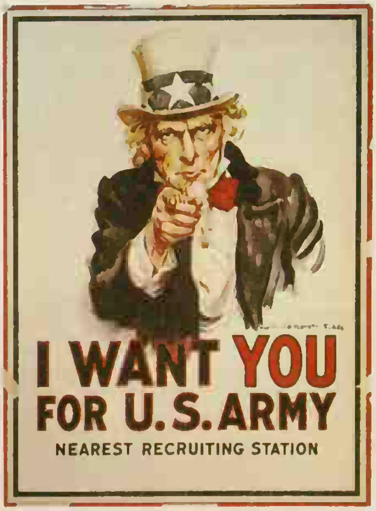
uncertainty principle Developed by Werner Heisenberg in 1927, the uncertainty principle states that there are absolute limits on the accuracy to which *pairs* of physical quantities can be measured. Classical physics sets no limit on the accuracy of the measurement of the position and the momentum of a particle. In contrast, one of the postulates of quantum mechanics is that the process of measurement itself disturbs the system being measured. Planck's constant h defines the size of the uncertainty. Because of the minuteness of h, the uncertainty is significant only when extremely small quantities are measured.

Heisenberg provided a number of physical illustrations of the uncertainty principle, for example, attempting to measure accurately the position of an atom by viewing it with an ideal microscope. After the light interacts with the atom it can be analyzed to determine the atom's position. The light, however, also imparts momentum to the atom by the Compton effect, which introduces uncertainty in the determination of that property.

The uncertainty principle, in its statement of the limits of observation, is a part of the present scientific view of the nature of physical reality.

Uncle Remus see Harris, Joel Chandler

Uncle Sam Uncle Sam is a symbolic character who is commonly employed in cartoons as the personification of

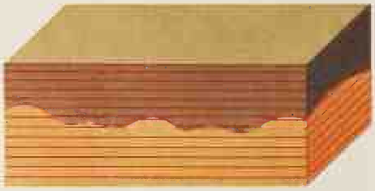


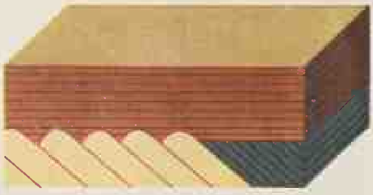
Uncle Sam is the widely recognized symbol for the United States. First created by cartoonists in the 1800s, Uncle Sam changed from a character of derision to one of respectability. In World Wars I and II, Uncle Sam was known as the patriotic figure of J. M. Flagg's army recruitment posters.

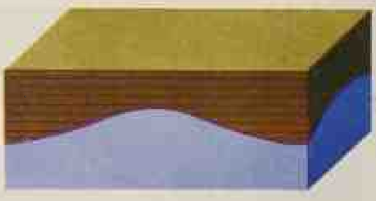
the United States. He is depicted as a tall, slender figure with long white hair and beard who is usually dressed in a swallow-tailed coat decorated with stars, a pair of striped trousers, and a top hat with stars and stripes on it. The name was first used in conjunction with the United States in a derogatory sense, by those opposing the War of 1812. Later in the 19th century cartoonists created a figure called Uncle Sam, which was used as a symbol for the country. It was cartoonist Thomas Nast who, in the 1870s, drew the figure commonly associated with Uncle Sam today. The most familiar depictions of Uncle Sam, however, are those drawn by James Montgomery Flagg and appearing on the recruiting posters that were used during World Wars I and II. Although the precise origins of the name are uncertain, in 1961 Congress recognized Uncle Sam as the namesake of Samuel Wilson (1766–1854), a Troy, N.Y., inspector of army supplies during the War of 1812.

Uncle Tom's Cabin Harriet Beecher STOWE's best-known novel, *Uncle Tom's Cabin; or, Life Among the Lowly*, first published serially in 1851–52, was an enormously popular tale of the injustices of slavery. Uncle Tom, an almost Christlike model of goodness and charity, is a house slave who is reluctantly sold by his first owners. He is ultimately beaten to death by Simon Legree, a tyrannical overseer, after many heartrending examples of generosity and heroism. Little Eva and Topsy are other memorable characters in the novel. Once believed to be a major cause of the Civil War, the novel did popularize the abolitionist movement. The term *Uncle Tom* is today used pejoratively to describe an African American who is too deferential to whites.

unconformity A substantial break in the sequence of deposition, which interrupts the geologic record, is called an unconformity. Charles Darwin, in *On the Origin of Species* (1859), emphasized the incompleteness of the geologic record as evidenced by numerous unconformities and argued that more geologic time is represented by breaks than by continuous deposits. This fact is certainly true for any single area on the continents. The task of the geologist, therefore, involves piecing together fragmentary local records to compile a more or less complete history of the Earth. The modern gathering of deep-ocean sediment cores makes available complete, almost continuous geologic records; deep-sea sediments, however, are seldom found older than about 200 million years.


A disconformity is recognized by the parallel structure of the rock layers above and below the unconformity, or break in the strata.


In an angular unconformity the older rock layers below the unconformity are deformed and tilted with respect to the younger layers above.


In a nonconformity the more recent sedimentary layers are laid down on a nonlayered surface of either igneous or metamorphic rocks.

unconscious Although thinkers and poets of many cultures and historical periods have understood the importance of an irrational realm of mental life essentially alien and unknown to the rational, conscious intellect, Sigmund FREUD is generally credited with having made the unconscious a cornerstone of modern clinical psychology and psychiatry. Freud created a model of the mind divided into conscious, preconscious, and unconscious regions or systems. The conscious system was said to contain those ideas of which the person was immediately aware. The preconscious system contained ideas of which the person was not immediately aware but could easily become so by simply turning attention to them. In contrast, the unconscious contained ideas of which the person could never become aware because their emergence into consciousness was prevented through a process termed repression.

Freud portrayed the unconscious system as a subterranean world of primitive urges and desires, repressed during childhood and relentlessly clamoring for expression and fulfillment through dreams, mistakes, and symptoms. Carl JUNG expanded this theory further by subdividing the unconscious into a personal unconscious, which was similar to Freud's concept, and a collective or transpersonal unconscious.

See also: PSYCHOANALYSIS.

Underground Railroad The term *Underground Railroad* referred to secret, organized efforts by Northerners in America's pre–Civil War decades to help escaped slaves find safe shelter in the free states or Canada. Such assistance was necessary because the Fugitive Slave Acts of 1793 and 1850 (see FUGITIVE SLAVE LAWS) allowed slaveowners to recapture their escaped slaves.

Despite Harriet TUBMAN's forays into the deep South to spirit slaves to freedom, most escaped slaves acted on their own. They made the most dangerous part of their trip—across the slave states to free territory—without organized help. Once they reached the free states, however, many were guided along prearranged Underground Railroad routes, receiving shelter, food, and clothing at various "stations," as the homes of the Railroad's supporters were known.

In general, it was northern free blacks, not white abolitionists, who played the most important role in the planning, communication, and decision making within the network of escape. The railroad was most active in Ohio, Indiana, and Pennsylvania, but it existed throughout the North. Most estimates of the number of slaves aided by the railroad fall between 50,000 and 100,000.

Underwood, Oscar W. Oscar Wilder Underwood, b. Louisville, Ky., May 6, 1862, d. Jan. 25, 1929, was a U.S. representative (1895–96, 1897–1915) and senator (1915–27) who cosponsored an important tariff act. An Alabama Democrat, Underwood was the chairman of the House Ways and Means Committee, in which capacity he sponsored and helped write the Underwood Tariff Act of 1913, a law that greatly reduced tariffs. In the Senate he was a supporter of President Woodrow Wilson's foreign policy and served as Democratic floor leader (1921–23). Underwood was an unsuccessful candidate for the Democratic presidential nomination in 1912 and 1924.

Undset, Sigrid [un'-set] The Norwegian novelist, Sigrid Undset, b. May 20, 1882, d. June 10, 1949, gained fame for her historical novels and in 1928 received the Nobel Prize for literature. Her first novels, however—*Fru Marta Oulie* (1907), *Jenny* (1911; Eng. trans., 1921), and *Images in a Mirror* (1917; Eng. trans., 1938)—deal with the role of modern women. The historical trilogy *Kristin Lavransdatter* (1920–22; Eng. trans., 1923–27), set in 14th-century Norway, ranks as one of the great works of Norwegian literature. It portrays the triumphs and tragedies of its protagonist, Kristin, from age 7 to her death in the plague 40 years later.

Undset converted to Catholicism in 1925, and her next historical novel, the tetralogy *The Master of Hestviken* (1925–27; Eng. trans., 1928–30), also set in medieval Norway, shows her increasing preoccupation with religious questions. From the 1930s on, she dealt with more contemporary issues. An early and forceful critic of Nazism, Undset fled to Sweden and then to the United States after the German invasion of Norway in 1940. She returned to Norway in 1945.

unemployment see EMPLOYMENT AND UNEMPLOYMENT

unemployment insurance Unemployment insurance is insurance against loss of pay when an employee loses his or her job. It is designed to provide unemployed workers with income for a limited period of time while they look for other jobs. In the United States federal law sets down guidelines and minimum standards for the program, to be financed by a payroll tax on employers with four or more employees. The individual states administer the program in cooperation with the federal government. Some states have elected to give insurance to workers excluded by the federal law, such as farm and domestic workers. The program covers more than 85 percent of the entire labor force.

The amount of the benefits paid differs in the various states. The rates generally take into account the applicant's previous level of earnings. (Ordinarily, the amount is one-half the applicant's previous salary up to a maximum that varies from state to state.) Another factor taken into consideration may be the number of the applicant's dependents. The normal length of the benefit period is 26 weeks, with 13-week increments in effect when the unemployment in a given area rises above a stated percentage.

To be eligible for unemployment insurance, persons must usually have worked a minimum period in a job—20 weeks in many states—or have earned a certain amount of money, or both. A worker can, however, be denied benefits if he or she quits a job without good cause or is fired because of misconduct. Unemployment benefits may also be denied if a worker is involved in a labor dispute that has brought about a work stoppage or if he or she refuses a suitable job without good cause.

Unemployment insurance was introduced in Western Europe early in the 20th century, the first such program being adopted by Great Britain in 1911. The U.S. program was an important element of the New Deal program of President Franklin D. Roosevelt. It was introduced in 1935 as part of the Social Security Act (see SOCIAL SECURITY).

UNESCO see UNITED NATIONS EDUCATIONAL, SCIENTIFIC, AND CULTURAL ORGANIZATION

Ungava [un-gah'-vuh] Ungava, a peninsular region of northeastern Canada, is bordered by Hudson Bay on the west and by the Labrador Sea on the east. Iron ore is the principal resource. Originally part of the Northwest Territories, Ungava was annexed to Quebec in 1912. In 1927 the eastern section of the peninsula became part of Newfoundland, and the name *Ungava* has since been used for the Quebec part of the region.

ungulate [uhng'-gue-luht] An ungulate is a mammal whose toes end in hooves made up of hardened skin tissue. Four orders of mammals can be classed as ungulates: the Artiodactyla, or even-toed ungulates, including deer, camels, cattle, pigs, giraffes, and sheep; the Perissodactyla, or odd-toed ungulates, including horses, donkeys, zebras, tapirs, and rhinoceroses; the Proboscidea, or elephants; and the Hyracoidea, or hyraxes.

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